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THE EVALUATION OF SOME THREADED INSERTS

Materials Integrity Branch
Systems Support Division

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Final Report for Period January 1975 to March 1978

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Pull Out Strength	Inserts from Parent Material
Corrosion	Installed Inserts

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This report presents: (1) fatigue data for 7075-T73 aluminum alloy plate containing threaded inserts; (2) the results of tests for determining the tensile load required to pull threaded insert out of the parent material; (3) the torque required to lock and unlock a bolt threaded into the insert and; (4) the susceptibility of the insert to corrosion when threaded into the parent material and exposed to a corrosive media. The types of threaded inserts evaluated consisted of solid wall bushings, helical coils, and the solid wall self-tapping bushings.

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FOREWORD

This evaluation was conducted by personnel of the Materials Integrity Branch, Air Force Materials Laboratory. This work was conducted in response to TN-ASD-AFML-1305-74-31, "Threaded Insert Evaluation." The work was conducted under Project No. 2418, Task No. 24180703. Alton W. Brisbane of AFML/MXA was the project engineer.

The evaluation was conducted during the period of January 1975 to December 1977. The author wishes to express his appreciation to Messers Robert Urzi, AFML/MXA, Richard Stewart, ASD/ENFEN, Richard Martin of UDRI, and Larry Salinas, ASD/SDZ8D for their assistance during the conduct of this program.

Data contained in this report shall not be used in any way for promotion or advertising purposes.

TABLE OF CONTENTS

SECTION		PAGE
I	INTRODUCTION	1
II	OBJECTIVE	3
III	THREADED INSERT SELECTION	4
	1. Solid Wall Inserts	4
	2. Helical Coil Inserts	6
	3. Self-Tapping Inserts	7
IV	INSERT MANUFACTURER AND INSERT DESIGNATIONS	8
V	TENSILE TESTS OF PARENT MATERIAL	9
VI	EXPERIMENTAL	10
	1. Specimen Preparation for Fatigue Tests	10
	2. Installation of Inserts	10
	3. Tools Required for Insert Installation	11
VII	FATIGUE TESTS	12
	1. Results	13
VIII	TENSILE STRENGTH PULL OUT SPECIMEN PREPARATION	14
	1. Experimental	14
	2. Results of Tensile Pull Out Tests	15
IX	LOCKING AND BREAKAWAY TORQUE TEST	16
	1. Specimen Preparation	16
	2. Results	16

TABLE OF CONTENTS (CONTINUED)

SECTION		PAGE
X	CORROSION TESTS	18
	1. Experimental	19
	2. Results of Corrosion Tests	19
XI	CONCLUSIONS	20
	REFERENCES	21
	APPENDIX	
I	STATISTICAL ANALYSIS OF THREADED INSERTS TEST DATA	123
	1. INTRODUCTION	124
	2. SUMMARY OF RESULTS	125
	3. STATISTICAL ANALYSIS	127
	3.1 Fatigue Tests	127
	3.1.1 Life Tests	127
	3.1.2 Breakaway Torques After Cyclic Loading	131
	3.2 Axial Strength Tests	132
	3.3 Locking and Breakaway Torque Tests	133

LIST OF ILLUSTRATIONS

FIGURE		PAGE
1	Solid Wall Type Inserts	5
2	Solid Wall Type Inserts	5
3	Helical Coil Inserts	6
4	Self Tapping Inserts	7
5	Tensile Test Specimen	80
6	Fatigue Specimen for 10-32 Insert	81
7	Fatigue Specimen for 1/4-28 Insert	82
8	Fatigue Specimen for 3/8-24 Insert	83
9	Installation Tools for Threaded Inserts. Also Shown Is the Heli-Coil Insert Removal Tool.	84
10	Alignment Fixture for Starting Groov-Pin Self-Tapping Insert	85
11	Fatigue Specimen with Inserts and Bolts Installed	86
12	Fatigue Specimen in MTS Universal Test Machine	87
13	Fractured Fatigue Specimen with Inserts	88

LIST OF ILLUSTRATIONS (CONTINUED)

FIGURE		PAGE
14	Bar Graph Showing the Fatigue Life of the 7075-T73 Alloy with 1/4-28 Inserts Only	89
15	Bar Graph Showing Fatigue Life of the 7075-T73 Alloy with 1/4-28 Inserts and Bolts	90
16	Bar Graph Showing the Fatigue Life of the 7075-T73 Alloy with 10-32 Size Inserts & Bolts Installed	91
17	Bar Graph Showing the Fatigue Life of 7075-T73 Alloy with 3/8-24 Size Inserts and Bolts	92
18	Insert Pull Out Specimens and Corrosion Specimen	93
19	Test Set-up for the Tensile Pull Out of Threaded Inserts	94
20	Locking and Unlocking Torque Specimen Lay Out	95
21	Typical Torque Wrench and Specimen for Locking and Breakaway Torque Tests	96
22	Close-up of Fatigue Failure of Specimens with Groov-Pin and Long-Lok 10-32 Size Inserts. Inserts Installed by Manufacture. Torqued Bolts in Insert During Tests.	97
23	Close-up of Fatigue Failures of Specimens with Rosan, Tridair, and Heli-Coil 10-32 Size Insert. Inserts Installed by Manufacture. Torqued Bolts in Inserts During Tests.	97
24	Close-up of Fatigue Failures of Specimens with Long-Lok Rosan, and Kaynar 10-32 Size Inserts. Inserts Installed by AFML. Torqued Bolts in Inserts During Tests.	98

LIST OF ILLUSTRATIONS (CONTINUED)

FIGURE		PAGE
25	Close-up of Fatigue Failures of Specimens with Tridair and Groov-Pin 10-32 Size Inserts. Inserts Installed by AFML. Torqued Bolts in Inserts During Tests.	98
26	Close-up of Fatigue Failure of Specimen with Heli-Coil Insert. Insert Installed by AFML. Torqued Bolts in Insert During Test.	99
27	Close-up of Fatigue Failure of Specimens with Rosan and Groov-Pin 1/4-28 Size Insert. Inserts Installed by Manufacture. Torqued Bolts in Inserts During Tests.	99
28	Close-up of Fatigue Failures of Specimens with Tridair and Long-Lok 1/4-28 Size Inserts. Inserts Installed by Manufacture. Torqued Bolts in Inserts During Tests.	100
29	Close-up of Fatigue Failure of Specimens with Heli-Coil 1/4-28 Size Inserts. Torqued Bolts in Inserts During Tests.	100
30	Close-up of Fatigue Failure of Specimens with Heli-Coil 1/4-28 Size Insert. Inserts Installed by AFML. Torqued Bolt in Inserts During Test.	101
31	Close-up of Fatigue Failure of Specimens with Rosan, Groov-Pin, and Long-Lok 1/4-28 Size Insert. Inserts Installed by AFML. No Bolt in Inserts.	101
32	Close-up of Fatigue Failure of Specimens with Heli-Coil, Tridair, and Kaynar 1/4-28 Size Inserts. Inserts Installed by AFML. No Bolt in Inserts.	102
33	Close-up of Fatigue Failures of Specimens with No Inserts. 1/4 Inch Diameter Holes.	102

LIST OF ILLUSTRATIONS (CONTINUED)

FIGURE		PAGE
34	Close-up of Fatigue Failure of Specimen with Rosan and Kaynar 1/4-28 Size Inserts. Inserts Installed by AFML. Torqued Bolts in Inserts During Tests.	103
35	Close-up of Fatigue Failures of Specimens with Groov-Pin and Tridair 1/4-28 Size Inserts. Inserts Installed by AFML. Torqued Bolts in Inserts During Tests.	103
36	Close-up of Fatigue Failure of Specimens with Long-Lok Insert. Inserts Installed by AFML. Torqued Bolts in Inserts During Test.	104
37	Close-up of Fatigue Failures of Specimens with Long-Lok and Heli-Coil 3/8-24 Size Inserts. Inserts Installed by AFML. Torqued Bolts in Inserts During Tests.	104
38	Close-up of Fatigue Fracture of Specimens with Tridair 3/8-24 Size Insert. Insert Installed by AFML. Torqued Bolt in Inserts During Test.	105
39	Close-up of Fatigue Failures of Specimens with Groov-Pin and Rosan 3/8-24 Size Inserts. Inserts Installed by AFML. Torqued Bolts in Inserts During Tests.	105
40	Close-up of Fatigue Failure of Specimens with Tridair and Groov-Pin 1/4-28 Size Insert. Inserts Installed by Manufacture.	106
41	Close-up of Fatigue Failures of Specimen with Rosan and Tridair 3/8-24 Size Inserts. Inserts Installed by Manufacture. Torqued Bolts in Inserts During Tests.	106
42	Close-up of Fatigue Failure of Specimens with Groov-Pin Size Inserts. Inserts Installed by Manufacture. Torqued Bolts in Inserts During Test.	107

LIST OF ILLUSTRATIONS (CONTINUED)

FIGURE PAGE

FIGURE		PAGE
43	Close-up of Fatigue Failure of Specimens with Heli-Coil 3/8-24 Size Inserts. Inserts Installed by Manufacture. Torqued Bolts in Inserts During Test.	107
44	Close-up of Fatigue Failure of Specimens with Heli-Coil and Rosan 1/4-28 Size Inserts. Inserts Installed by Manufacture. No Bolt in Inserts.	108
45	Close-up of Fatigue Failure of Specimens with Long-Lok 1/4-28 Size Inserts. Inserts Installed by Manufacture. No Bolts in Inserts.	108
46	Corrosion Specimen with Washer and Bolt	109
47	Corrosion Specimen	110
48	Corrosion Specimen	111
49	Corrosion Specimen	112
50	Corrosion Specimen	113
51	Corrosion Specimen	114
52	Corrosion Specimen	115
53	Corrosion Specimen	116
54	Corrosion of Parent Material Surface	117
55	Corrosion Specimen with Bolt Removed	118

LIST OF ILLUSTRATIONS (CONTINUED)

FIGURE		PAGE
56	Corrosion Specimen after Cleaning	119
57	Corrosion Specimen after Cleaning	119
58	Corrosion Specimen after Cleaning	120
59	Corrosion Specimen after Cleaning	120
60	Corrosion Specimen after Cleaning	121
61	Corrosion Specimen after Cleaning	121
62	Corrosion Specimen after Cleaning	122
63	Average Life for Manufacturers - 1/4-28 Tests	141
64	Average Life for Manufacturers - 10-32 Tests	142
65	Average Life for Manufacturers - 3/8-24 Tests	143
66	Average Breakaway Torque Differences - 10-32 Fatigue Tests	144
67	Average Breakaway Torque Differences - 1/4-28 Fatigue Tests	145
68	Average Breakaway Torque Differences - 3/8-24 Fatigue Tests	146
69	Average Axial Strengths - 10-32 Size Specimens	147
70	Average Axial Strengths - 1/4-28 Size Specimens	148

LIST OF ILLUSTRATIONS (CONTINUED)

FIGURE		PAGE
71	Average Axial Strengths - 3/8-24 Size Specimens	149
72	Average Bolt Locking/Unlocking Torques for Repeated Applications - Kaynar Inserts	150
73	Average Bolt Locking/Unlocking Torques for Repeated Applications - Rosan Inserts	151
74	Average Bolt Locking/Unlocking Torques for Repeated Applications - Heli-Coil Inserts	152
75	Average Bolt Locking/Unlocking Torques for Repeated Applications - Tridair Inserts	153
76	Average Bolt Locking/Unlocking Torques for Repeated Applications - Long-Lok Inserts	154
77	Average Bolt Locking/Unlocking Torques for Repeated Applications - Torkon Inserts	155
78	Average Bolt Locking/Unlocking Torques for Repeated Applications - Groov-Pin Inserts	156

LIST OF TABLES

TABLE		PAGE
1	Insert Sizes and Identification for Evaluation Program	8
2	Results of Tensile Strength Tests of 7075-T73 Aluminum Alloy - Plate	9
3	Breakaway Torque Before and After Fatigue Tests - Bolt Initially Torqued to 35 In-Lbs	22
4	Breakaway Torque Before and After Fatigue Tests - Bolt Initially Torqued to 70 In-Lbs	23
5	Breakaway Torque Before and After Fatigue Tests - Bolts Initially Torqued to 245 In-Lbs	24
6	Breakaway Torque Before and After Fatigue Tests - Bolt Initially Torqued to 35 In-Lbs	25
7	Breakaway Torque Before and After Fatigue Tests - Bolt Initially Torqued to 70 In-Lbs	26
8	Breakaway Torque Before and After Fatigue Tests - Bolts Initially Torqued to 245 In-Lbs	27
9	Breakaway Torque Before and After Fatigue Tests - Bolt Initially Torqued to 35 In-Lbs	28
10	Breakaway Torque Before and After Fatigue Tests - Bolt Initially Torqued to 70 In-Lbs	29
11	Breakaway Torque Before and After Fatigue Tests - Bolts Initially Torqued to 245 In-Lbs	30

LIST OF TABLES (CONTINUED)

TABLE		PAGE
12	Breakaway Torque Before and After Fatigue Tests - Bolt Initially Torqued to 35 In-Lbs	31
13	Breakaway Torque Before and After Fatigue Tests - Bolt Initially Torqued to 70 In-Lbs	32
14	Breakaway Torque Before and After Fatigue Tests - Bolts Initially Torqued to 245 In-Lbs	33
15	Breakaway Torque Before and After Fatigue Tests - Bolt Initially Torqued to 35 In-Lbs	34
16	Breakaway Torque Before and After Fatigue Tests - Bolt Initially Torqued to 70 In-Lbs	35
17	Breakaway Torque Before and After Fatigue Tests - Bolts Initially Torqued to 245 In-Lbs	36
18	Breakaway Torque Before and After Fatigue Tests - Bolt Initially Torqued to 35 In-Lbs	37
19	Breakaway Torque Before and After Fatigue Tests - Bolt Initially Torqued to 70 In-Lbs	38
20	Breakaway Torque Before and After Fatigue Tests - Bolts Initially Torqued to 245 In-Lbs	39
21	Breakaway Torque Before and After Fatigue Tests - Bolt Initially Torqued to 35 In-Lbs	40
22	Breakaway Torque Before and After Fatigue Tests - Bolt Initially Torqued to 70 In-Lbs	41

LIST OF TABLES (CONTINUED)

TABLE		PAGE
23	Breakaway Torque Before and After Fatigue Tests - Bolts Initially Torqued to 245 In-Lbs	42
24	The Average Breakaway Bolt Torque Before and After Fatigue Tests	43
25	Results of Fatigue Tests of 7075-T73 Aluminum Alloy with 1/4-28 Threaded Holes and Smooth Holes	44
26	Results of Fatigue Tests of 7075-T73 Aluminum Alloy with 1/4-28 Threaded Inserts Only	45
27	Results of Fatigue Tests of 7075-T73 Aluminum Alloy with Heli-Coil Threaded Insert and Bolt Installed	46
28	Results of Fatigue Tests of 7075-T73 Aluminum Alloy with Tridair Threaded Insert and Bolt Installed	47
29	Results of Fatigue Tests of 7075-T73 Aluminum Alloy with Rosan Threaded Insert and Bolt Installed	48
30	Results of Fatigue Tests of 7075-T73 Aluminum Alloy with Kaynar Threaded Insert and Bolt Installed	49
31	Results of Fatigue Tests of 7075-T73 Aluminum Alloy with Long-Lok Threaded Insert and Bolt Installed	50
32	Results of Fatigue Tests of 7075-T73 Aluminum Alloy with Torkon Threaded Insert and Bolt Installed	51
33	Results of Fatigue Tests of 7075-T73 Aluminum Alloy with Groov-Pin Threaded Insert and Bolt Installed	52
34	Percentage Increase or Decrease of the Fatigue Life of 7075-T73 Alloy with Threaded Holes When 1/4-28 Inserts Are Added or When Inserts and Bolts Are Added	53

LIST OF TABLES (CONTINUED)

TABLE		PAGE
35	Room Temperature Axial Strength Tests	54
36	Pull Out Tensile Strength Averages of Inserts Installed in 7075-T73 Aluminum	56
37	Room Temperature Locking Unlocking Torque Tests	58
38	Room Temperature Locking Unlocking Torque Tests	59
39	Room Temperature Locking Unlocking Torque Tests	60
40	Room Temperature Locking Unlocking Torque Tests	61
41	Room Temperature Locking Unlocking Torque Tests	62
42	Room Temperature Locking Unlocking Torque Tests	63
43	Room Temperature Locking Unlocking Torque Tests	64
44	Room Temperature Locking Unlocking Torque Tests	65
45	Room Temperature Locking Unlocking Torque Tests	66
46	Room Temperature Locking Unlocking Torque Tests	67
47	Room Temperature Locking Unlocking Torque Tests	68
48	Room Temperature Locking Unlocking Torque Tests	69
49	Room Temperature Locking Unlocking Torque Tests	70

LIST OF TABLES (CONTINUED)

TABLE		PAGE
50	Room Temperature Locking Unlocking Torque Tests	71
51	Room Temperature Locking Unlocking Torque Tests	72
52	Room Temperature Locking Unlocking Torque Tests	73
53	Room Temperature Locking Unlocking Torque Tests	74
54	Room Temperature Locking Unlocking Torque Tests	75
55	Room Temperature Locking Unlocking Torque Tests	76
56	Room Temperature Locking Unlocking Torque Tests	77
57	Room Temperature Locking Unlocking Torque Tests	78
58	Averages of the First Cycle, Seventh Cycle and Fifteenth Cycle of the Locking and Breakaway Torque Test for Each Size Insert	79
59	Fatigue Lives from 1/4-28 Tests (K Cycles to Failure)	134
60	Analysis of Variance Table for Fatigue Lives from 1/4-28 Tests	135
61	Analysis of Variance Table for Fatigue Lives from 10-32 Tests	135
62	Analysis of Variance Table for Fatigue Lives from 3/8-24 Tests	136
63	Analysis of Variance Table for Breakaway Torque Differences - 10-32 Fatigue Tests	136
64	Analysis of Variance Table for Breakaway Torque Differences - 1/4-28 Fatigue Tests	137

LIST OF TABLES (CONTINUED)

TABLES		PAGE
65	Analysis of Variance Table for Breakaway Torque Differences - 3/8-24 Fatigue Tests	137
66	Analysis of Variance Table for Axial Strength - 10-32 Size Specimens	138
67	Analysis of Variance Table for Axial Strength - 1/4-28 Size Specimens	138
68	Analysis of Variance Table for Axial Strength - 3/8-24 Size Specimens	139
69	Percent Reduction of Average Locking and Breakaway Torques	140

SECTION I

INTRODUCTION

There are currently many types of threaded metal inserts which are commercially available. These inserts are used to allow the fastening of one material with screws or bolts to another material without having the screw or bolt threaded directly into the second material. The last overall testing of threaded inserts was accomplished about 1964. Many of the products tested then are no longer available. Therefore, it was desirable to test several of the currently available inserts to characterize mechanical and corrosion characteristics.

Threaded inserts are used in many of the softer materials such as aluminum, magnesium, and nonmetallics. The hard material of the insert can withstand the frequent removal of the screws or bolts more so than the soft materials.

The number and type of insert systems was necessarily limited due to the cost and manpower involved in an evaluation program. The particular systems selected were chosen to be representative of systems found in aircraft structure. In general the program was limited to not more than two products of a given type (e.g., self-tapping) and only one type of threaded insert from each manufacturer.

The evaluation of threaded inserts reported herein was requested by the Deputy for Engineering, Flight Equipment Division, Mechanical Branch of the Air Force Aeronautical Systems Division, (ASD/ENFEM). The inserts were tested for static pullout strength, the effect of insert on fatigue life of parent material with and without fasteners installed, locking and unlocking torque of the fastener, and corrosion susceptibility. The approach was to have the participating insert manufacturers install inserts in half of the specimens to be tested. The other half were installed at the AFML. Testing of all the inserts was accomplished by the Air Force Materials Laboratory, Systems Support Division, Materials Integrity Branch (AFML/MXA) at Wright-Patterson AFB.

SECTION II

OBJECTIVE

The main objective of this program was to provide engineering test data on threaded inserts, for general use in airframe structures. The information derived from this study in conjunction with data from other sources can be used in evaluating insert systems for Air Force use.

SECTION III

THREADED INSERT SELECTION

The tests were designed to determine several characteristics of the threaded insert system.

The following insert types were selected as being representative of those found in typical aircraft structures: (1) solid wall bushing type inserts, (2) wire coil type inserts, and (3) a self-tapping type insert. All of the inserts were the self-locking type, internal and external.

1. SOLID WALL INSERTS

There are several varieties of the solid wall bushing type insert. For this evaluation program the non-self-tapping solid wall inserts used are shown in Figure 1. Both of the inserts shown have a thin wall made of type 303 stainless steel. These inserts have an integral plastic (nylon) self-locking element which extends through the wall of the inserts. On one type the plastic is longitudinal in the threads and in the other the plastic is radial in the threads. A dry film lubricant is used on the insert to prevent galling and seizing between the internal threads of the insert and the bolts and it also prevents seizing on installation. The inserts shown in Figure 1 can be installed into the parent material either end first.

The other variety of solid wall inserts are shown in Figure 2. Both of these inserts also have a thin wall. One is made of CRES PH 17-4 stainless steel heat treated to 180-200 KSI. The other insert is made of a heat treated alloy steel and is cadmium plated. Both inserts are coated with a dry film lubricant. The internal thread locking mechanism for both inserts is mechanical caused by deformed thread shape. The two inserts also have external locking in which the area at the top of the insert is serrated. The serrated area is swaged outward into the parent material during installation locking the insert to the parent material.

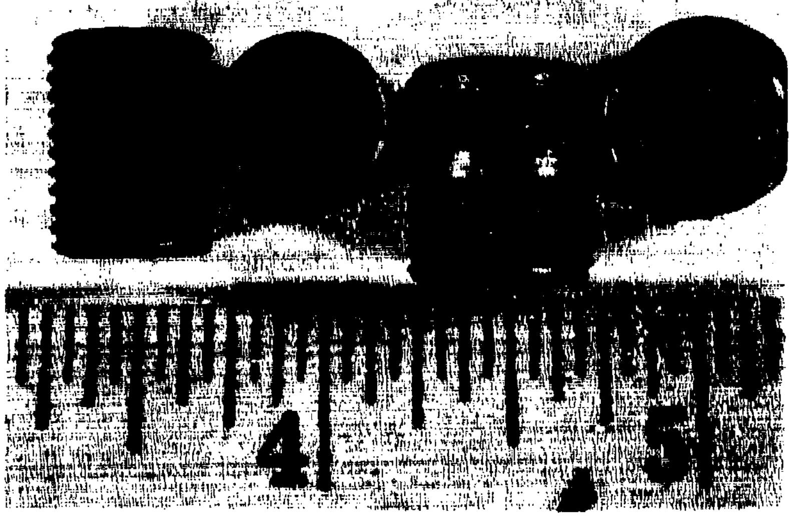

Figure 1. Solid Wall Type Inserts

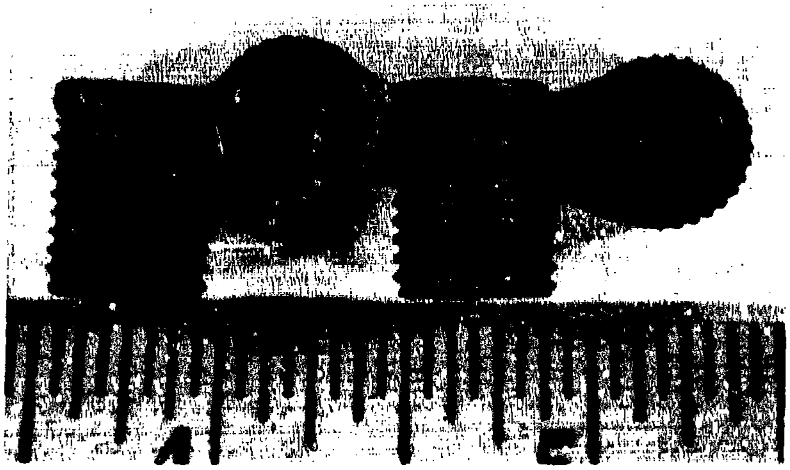

Figure 2. Solid Wall Type Insert

2. HELICAL COIL INSERTS

The two helical coil type inserts operate on the same principle. These inserts are shown in Figure 3. In the free state the diameter of the insert is larger than the tapped hole in which it will be installed. In assembly the insert is reduced in diameter, threaded into place, and retained by the insert attempting to expand to its original diameter. Internal locking between the insert and the bolt is achieved by a series of cords on one or more of the insert convolutions. The threading of the holes for the coil wire inserts requires a tap designed for wire inserts.

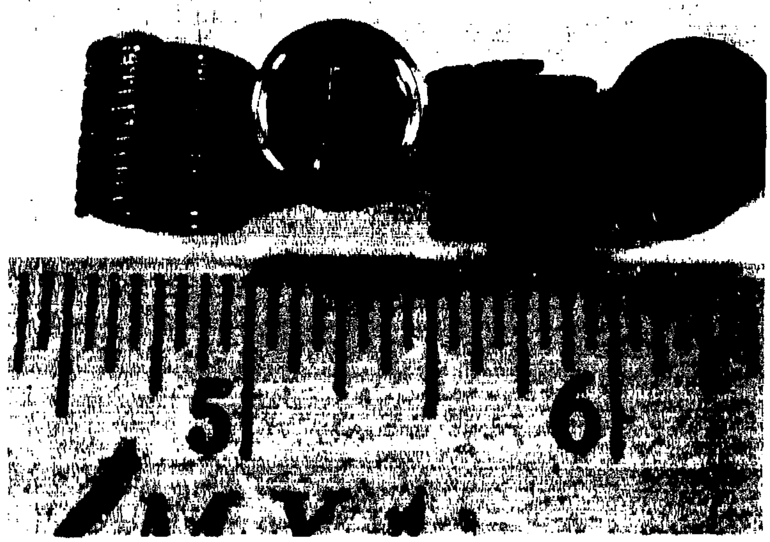

Figure 3. Helical Coil Insert

3. SELF-TAPPING INSERT

The self-tapping insert is a bushing with internal and external threads. The insert is designed to cut its own threads as it is screwed into a drilled or cored hole. The cutting edges are formed by several transverse holes drilled through the wall of the pilot portion of the insert as shown in Figure 4. These transverse holes also allow for the discharge of chips during the self-tapping operation. The insert material is hardened stainless steel. The internal and external thread locking mechanism is a nylon pellet pressed into a hole drilled through the wall of the insert.

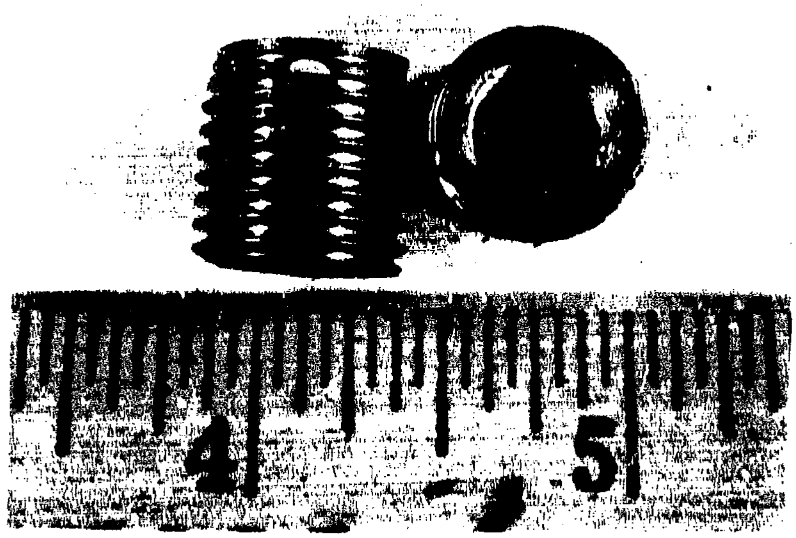

Figure 4. Self-Tapping Insert

SECTION IV

INSERT MANUFACTURER AND INSERT DESIGNATIONS

The seven insert manufacturers and the insert designation are shown in Table 1.

TABLE 1

INSERT SIZES AND IDENTIFICATION FOR EVALUATION PROGRAM

Insert Mfg.	10-32 Size* Length	Part No.	1/4-28 Size* Length	Part No.	3/8-24 Size* Length	Part No.
Groov-Pin	.296	NM-19032-90	.375	NM-25028-90	.562	NM-37524-90
Long-Lok	.290±.01	T 02 P59	.380±.01	T 048 P59	.560±.01	T 064 P59
Heli-Coil	.285	3591-3CN-0285	.375	3591-4CN-0375	.562	3591-6CN-0562
Kaynar	.300Max	K8000-3	.390Max	K8000-4	.570Max	K8000-6
Rosan	.290±.01	SR-192L	.380±.01	SR-258-L	.560±.01	SR-374L
Tridair	.285	TLF-3C-0285	.375	TLF-4C-0375	.562	TLF-6C-0562
Torkon	.290±.01	Ti 1011-117	.380±.01	Ti 1011-119	.560±.01	Ti 1011-223

Open hole threaded specimen will be from the 1/2 inch plate with 1/4-28 tap threads only.

* 10-32 parts were installed in .312" plate
1/4-28 parts were installed in .500" plate
3/8-24 parts were installed in .750" plate

± Length values are shown only when specified by the manufacturer.

SECTION V

TENSILE TESTS OF PARENT MATERIAL

Tensile specimens from each thickness of material were machined in accordance with the drawing shown in Figure 5.

Six tensile specimens were prepared from each thickness of the 7075-T73 plate material. The plate thicknesses were 5/16-inch, 1/2-inch and 3/4-inch. The tensile test specimens were tested in a 10,000-pound capacity Instron test machine. The specimens were tested at ambient temperature and at a strain rate of 0.005 inch/inch per minute. The mechanical properties of the 7075-T73 aluminum alloy are given in Table 2.

TABLE 2

RESULTS OF TENSILE STRENGTH TESTS OF 7075-T73 ALUMINUM ALLOY - PLATE

SPEC. NO.	MATERIALS THICKNESS	YIELD STRESS KSI	ULTIMATE STRESS KSI	ELONGATION % - 1" G.L.	REDUCTION IN AREA - %
1	5/16"	53.5	65.7	13.0	29.0
2	"	54.0	65.1	11.0	31.0
3	"	54.5	65.4	12.0	33.0
4	"	53.5	65.6	12.0	31.0
5	"	53.6	65.7	11.0	31.0
6	"	53.9	65.2	13.0	32.0
	AVERAGE ----	53.8	65.45	12.0	31.2
1	1/2"	50.9	63.7	14.0	38.0
2	"	50.9	64.1	15.0	39.0
3	"	51.7	63.7	15.0	38.0
4	"	50.9	64.1	14.0	38.0
5	"	50.5	63.7	16.0	38.0
6	"	50.5	63.5	16.0	38.0
	AVERAGE ----	50.9	63.8	15.0	38.2
1	3/4"	56.6	69.7	14.0	33.0
2	"	56.4	69.7	13.0	31.0
3	"	55.1	68.2	13.0	31.0
4	"	56.6	69.3	13.0	33.0
5	"	56.0	69.2	12.0	33.0
6	"	57.4	70.3	13.0	33.0
	AVERAGE ----	56.3	69.4	13.0	32.3

SECTION VI

EXPERIMENTAL

1. SPECIMEN PREPARATION FOR FATIGUE TESTS

The fatigue specimens were made as shown in Figures 6, 7, and 8. The specimens were machined by the Millat Industries Corporation, Dayton, Ohio. The aluminum material was received in the 7075-T6 condition and was over-aged to the 7075-T73 condition. Fatigue specimens for the 10-32 size inserts were machined from 5/16-inch thick aluminum, the fatigue specimens for the 1/4-28 size inserts were machined from 1/2-inch thick aluminum plate and the fatigue specimens for the 3/8-24 size inserts were machined from 3/4-inch thick aluminum plate.

The insert holes were prepared in accordance with the manufacturers' recommended instructions. All holes were checked after they were tapped for go/no-go. The tapped holes for the wire inserts required a tap designed for helical coil inserts.

2. INSTALLATION OF INSERTS

The installation of the various inserts required installation tools designed for that type of insert. These tools were furnished by the participating insert manufacturers. The program was set up so that the manufacturers would install inserts in one half of the specimens to be evaluated. These specimens were shipped to the manufacturers for installation of the inserts. AFML installed the inserts in the remaining half of the specimens at WPAFB.

The Long-Lok, Torkon, Tridair, Heli-Coil, and Groov-Pin inserts required only one operation for installation after hole preparation. The Kaynar and the Rosan inserts required two operations for installation after hole preparation. These two inserts had to be first screwed into the parent material and then the top knurled portion of the insert swagged into the wall of the parent material so as to prevent rotation of the insert. An alignment fixture was used for starting the self-tapping insert. The alignment fixture was used to ensure against the insert being threaded into the hole eccentrically. Such a fixture is not normally used in actual aircraft production. The self-tapping insert required much more installation torque than the inserts with the pre-tapped holes. The 3/8-24 size self-tapping insert required an average installation torque of 69 foot/pounds. It was not determined what the torque was for tapping the threads for the pre-threaded holes.

When installing the Heli-Coil and Tridair inserts care has to be taken so that the threads of the insert and the parent material are not mismatched. After the installation of the insert, the tang which is used to drive the insert was broken off. The Heli-Coil installation tool was used to install both Heli-Coil and Tridair inserts.

3. TOOLS REQUIRED FOR INSERT INSTALLATION

The tools used for installing the inserts are shown in Figures 9 and 10. Tools for installation are available in automatic and manual varieties. All inserts were installed with the manual tools for this program.

SECTION VII

FATIGUE TESTS

The fatigue testing phase of the evaluation was to determine the effect that the insert had on the fatigue life of the parent material and the effect of fatigue loading on the breakaway torque of the insert system.

In order to obtain control fatigue data, specimens from 1/2-inch thick aluminum plate were tested in the tapped open hole condition and also with only the insert installed in the hole.

A fatigue specimen with the bolts installed in the inserts is shown in Figure 11. A washer with a recessed hole was installed under the bolt head so that when the bolt was torqued down there would be a load transfer through the bolt into the insert and into the parent material. The 10-32 size bolt was torqued to 35 inch-pounds, the 1/4-28 size bolt was torqued to 70 inch-pounds, and the 3/8-24 size bolt was torqued to 245 inch-pounds. The initial torque for each size bolt was recorded. The breakaway torque before starting the test was also recorded. The bolt was then retorqued to the original value and the specimens were cycled to failure or 10^6 cycles. After failure of the parent material the breakaway torque of the two remaining bolts was recorded. The torque data are shown in Tables 3 through 23.

All fatigue specimens were cycled at 50 percent of the parent material (7075-T73) ultimate tensile stress.

The test machine used to conduct the fatigue tests was a MTS 50 KIP capacity universal fatigue test machine. The test set up is shown in Figure 12. All tests were conducted at room temperature in ambient air.

All of the fatigue tests were conducted at a stress ratio of Min. Stress/ Max. Stress of 0.1 (tension-tension). The test frequency was 25 Hz for the 5/16-inch and 1/2-inch thick material and 15 Hz for the 3/4-inch thick material.

1. RESULTS

Fatigue tests on the 7075-T73 alloy were conducted on specimens with: (1) threaded holes, (2) with inserts in the threaded holes, and (3) bolts installed in the inserts. A statistical analysis indicates that the installation of the inserts alone increased the fatigue life over the threaded holes for all cases except for specimens with Torkon and Groov-Pin inserts. This analysis is based on data taken from Tables 25 and 26 and the results are shown in Table 34. Additional tests with bolts installed in the inserts indicated a further increase in fatigue life for all specimens including the specimens with Torkon and Groov-Pin inserts; although the overall increase for specimens with Torkon and Groov-Pin inserts when compared with the threaded hole only, was less. More important; however, is the total fatigue life of the overall system with the fastener installed.

The results of all of the fatigue test data are tabulated in Tables 25 through 33 and summarized in the bar graphs shown in Figures 14 through 17. The pattern of the fatigue failures did not seem to change between the 5/16-inch (10-32 inserts) thick plate, the 1/2-inch (1/4-28 inserts) thick plate, and the 3/4-inch (3/8-24 inserts) thick plate. A failed fatigue specimen is shown in Figure 13. Photo macrographs of representative failed specimens are shown in Figures 22 through 45. The averages of the breakaway torque before and after fatigue testing are shown in Table 24. In general the breakaway torque either increased or remained essentially the same. Above tests were for 1/4-28 inserts only. Results of other size inserts with bolts are shown in bar graphs in Figure 16 and Figure 17.

SECTION VIII

TENSILE STRENGTH PULL OUT SPECIMEN PREPARATION

The specimens as shown in Figure 18 were machined by Millat Industries Corporation, Dayton, Ohio. The specimens were machined from 1-1/2 inch diameter 7075-T73 aluminum bar. The holes for all three sizes of inserts (10-32, 1/4-28, 3/8-24) were drilled and tapped in accordance with the insert manufacturer's recommended instructions. All holes were checked for go/no-go. The installation of all inserts were the same as detailed in the section on insert installation.

1. EXPERIMENTAL

The tensile strength pull out tests were conducted on a 50,000-pound capacity FGT testing machine. All tensile tests for insert pull out were conducted at room temperature at a loading rate of approximately 100 KSI per minute. The test set up is shown in Figure 19. The bolts used were as follows. Bolts for the 10-32 size inserts were part number BM55132-3-30A, bolts for the 1/4-28 size inserts were part number BM9022-4-36, and the bolts used for the 3/8-24 size inserts were part number BM3306-6-35. The bolt material was H-11 steel.

The length of all inserts was approximately 1-1/2 times the insert diameter. The inserts were installed in the specimens to a depth equaling the full length of the insert. The bolt used for pulling the insert out of the parent material was screwed into the insert until two threads of the bolt extended beyond the length of the insert. A new bolt was used for each test.

Tensile strength pull out tests were performed on six specimens of each size submitted by all seven manufacturers. All tensile tests were conducted to failure so as to establish the ultimate pull out load of the installed insert or the failure load of the bolt.

2. RESULTS OF TENSILE PULL OUT TESTS

The results of the axial strength tests is given in Table 35.

The type of axial strength test failure for all of the inserts tested was either the bolt failed or the threads of the parent material pulled out. There was never a failure of the insert material or the bolt threads stripping off. In Table 35, it is indicated by an asterisk (*) denoting the tests in which the bolt failed prior to insert pull out. Shown in Table 36 is an average of the axial tensile strength of the inserts according to type.

SECTION IX

LOCKING AND BREAKAWAY TORQUE TESTS

1. SPECIMEN PREPARATION

The inserts of all three sizes were installed in a 1" X 3" X 12" 7075-T73 aluminum plate as shown in Figures 20 and 21. A separate plate was used for each manufacturer's insert. The insert installation procedures were the same as previously stated. The tests were performed in accordance with the general provisions of Specification MIL-N-25027C. In all cases cadmium plated steel bolts were used. Each test consisted of 15 locking and breakaway cycles. The locking and breakaway torque were recorded for each cycle. A new bolt was used for each 15 cycle test. The 1" X 3" X 12" plate was clamped to the surface of a work bench. All tests were accomplished manually. The torque wrenches used were as follows: for the 10-32 inserts a Sturtevant Memory Model MC25-1, 0-25 inch-pounds; for the 1/4-28 inserts, a Sturtevant Memory Model MC50-1, 0-50 inch-pounds wrench; and for the 3/8-24 size inserts, a Sturtevant Memory Model MC300-1, 0-300 inch-pounds wrench was used. To start the test, the test bolt was finger screwed into the insert to the locking mechanism. Then using the torque wrench the bolt was screwed several revolutions into the insert making sure the locking mechanism was fully engaged. All inserts had both external and internal locking mechanisms. There were three types of locking mechanisms; nonmetallic, metallic and what Heli-Coil and Tridair refer to as resilient locking thread.

2. RESULTS

The results of the locking and breakaway torque tests for the 10-32 size inserts are given in Tables 37 through 43. There is no data for the 10-32 size inserts installed by Kaynar because the specimens were not returned to AFML. The results of the locking and breakaway torque tests for the 1/4-28 inserts are given in Tables 44 through 50. The results of the locking and breakaway torque tests for the 3/8-24 size inserts are given in Tables 51 through 57. The average of first cycle locking and breakaway torque, the average of the seventh cycle locking and breakaway torque, and the average of the 15th cycle locking and breakaway torque for each size insert and for each manufacturer is given in Table 58.

During the torque tests no rotation of inserts were observed. There was only one noticeable abnormality. During the testing of one of Tridair's 10-32 inserts after five cycles the insert lost its lockability. The torque was not measurable, and the bolt could be screwed past the locking mechanism with fingers.

SECTION X

CORROSION TESTS

The corrosion test specimens were machined as shown in Figure 18. The specimens were made from 1-1/2 inch diameter 7075-T73 aluminum. Specimens were made only for the 1/4-28 size inserts. The installation of all inserts was the same as detailed in the section on insert installation.

Prior to the installation of inserts into the corrosion specimen, and after all machining was completed, the specimen blocks were treated with MIL-C-5541 chemical surface treatment.

1. EXPERIMENTAL

The corrosion test specimens consisted of 42, 1-1/2 inch dia., 1-inch long aluminum block. A 1/4-28 hole was made in each blank. Then six 1/4-28 size inserts from each manufacturer were installed. Each specimen was then assembled with NAS 1351 series bolt and a corrosion resistant washer as shown in Figure 46. Each 1/4-28 bolt was torqued to 70 inch-pounds. The corrosion tests were conducted in accordance with ASTM-G44-75. The corrosion media was 3-1/2 percent NaCl solution. The specimens were immersed in the solution for ten minutes and out of solution for 50 minutes. This procedure was repeated for 30 days.

The corrosion media was changed weekly. The specimens were examined periodically during the 30-day corrosion test.

After the completion of the 30-day corrosion test, the specimens were sectioned in half with the bolt still intact. Due to the hardened surface of the Groov-Pin inserts, it was not possible to cut through that insert with the saw being used.

2. RESULTS OF CORROSION TESTS

The corrosion test specimens were sectioned in half after the completion of the alternate immersion corrosion tests. Figures 47 through 53 show the specimens immediately after sectioning with corrosion products in place, and Figures 56 through 62, show the same specimens after cleaning. All of the specimens showed evidence of pitting corrosion in the lower portion of the drilled hole below the insert. Surprisingly, and considering the lack of any sealant or other protective medium, no evidence of corrosion was observed at the insert-parent material interface of any of the inserts configuration except for the self-tapping. Pitting was observed throughout the length of the hole in the parent material where the self-tapping insert was used. At least part of this corrosion was due to the intrusion of the corrosive medium through the transverse cutting holes. It is possible that the corrosion was due to a lack of plating on the self-tapping insert. In no case was there evidence of any corrosion of any of the insert material including the self-tapping insert material.

It is emphasized that these corrosion tests were conducted under laboratory conditions, limiting the total exposure period to approximately 720 hours under no loads. Long-term field effects of corrosion should not be predicted from these results.

SECTION XI

CONCLUSIONS

The work in this report was conducted at the request of the Air Force Aeronautical Systems Division to obtain data necessary for the design of structures containing various types of inserts. While the inserts varied in relative performance under different conditions, none failed to meet any Air Force standards or requirements. Obviously many other factors including cost, availability, etc. should be considered in making insert selections. With this in mind, the following conclusions are offered.

1. It was found that hole preparation is very important. The hole for the self-tapping insert is less critical than for the pre-tapped hole. The hole should not be out of round. If it is, the threads cut will not be uniform in depth.

2. The torque required when installing the larger diameter self-tapping insert is relatively high. The torque required to install the 3/8-24 size insert in the 7075-T73 alloy was greater than 60 ft-lbs.

3. The fatigue life of the parent material with a threaded hole was generally increased by the installation of an insert. The fatigue life of the parent material insert system was further increased when a bolt was installed and torqued to the specified load.

4. The breakaway torque of the bolts in the inserts was measured after fatigue cycling and showed increased values over the initial measured breakaway torque.

5. In the tensile pull out test the threads of the parent material sheared or the bolt itself failed.

6. The locking and breakaway torque of the bolts were highest after the first few torque cycles. The locking and breakaway torque declined thereafter to a point where they seem to level out for the remainder of the test.

7. There was no evidence of corrosion of the inserts installed in the 7075-T73 aluminum alloy or of the threads of the parent material, except for the threads of the parent material with self-tapping inserts which were not plated.

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TABLE 3

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLT INITIALLY TORQUED TO 35 IN-LBS

KAYNAR INSERTS

10-32, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	26.4	28.8	27.6
BEFORE TEST	C	25.2	33.6	32.4
BEFORE TEST	B	30	32.4	31.2
AFTER TEST	T	32.4	---	26.4
AFTER TEST	C	---	28.8	---
AFTER TEST	B	36.0	26.4	28.8

10-32, FACTORY INSTALLED

	HOLE LOCATION	TEST 1	TEST 2	TEST 3
BEFORE TEST	T	26.4	32.4	28.8
BEFORE TEST	C	26.4	31.2	27.6
BEFORE TEST	B	25.2	30.0	31.2
AFTER TEST	T	---	43.2	25.2
AFTER TEST	C	27.6	28.8	26.4
AFTER TEST	B	25.2	---	---

NOTE: T = TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

TABLE 4

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLT INITIALLY TORQUED TO 70 IN-LBS

KAYNAR INSERTS

1/4-28, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	54	55.2	57.6
BEFORE TEST	C	54	55.2	57.6
BEFORE TEST	B	52.8	55.2	60
AFTER TEST	T	49.2	54	62.4
AFTER TEST	C	66	---	---
AFTER TEST	B	---	57.6	55.2

1/4-28, FACTORY INSTALLED

	HOLE LOCATION	TEST 1	TEST 2	TEST 3
BEFORE TEST	T	52.8	49.2	60
BEFORE TEST	C	55.2	52.8	67.2
BEFORE TEST	B	61.2	49.2	61.2
AFTER TEST	T	51.6	---	---
AFTER TEST	C	52.8	61.2	50.4
AFTER TEST	B	---	48	45.6

NOTE: T = TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

TABLE 5

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLTS INITIALLY TORQUED TO 245 IN-LBS

KAYNAR INSERTS

3/8-24, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	194.4	177.6	188.4
BEFORE TEST	C	192.0	177.6	194.4
BEFORE TEST	B	192.0	164.4	174.8
AFTER TEST	T	---	277.2	271.2
AFTER TEST	C	247.2	289.2	---
AFTER TEST	B	256.8	---	184.8
3/8-24, FACTORY INSTALLED				
BEFORE TEST	T	204	183.6	187.2
BEFORE TEST	C	198	249.6	188.4
BEFORE TEST	B	195.6	284.4	122.4
AFTER TEST	T	---	---	360.0
AFTER TEST	C	303.6	332.4	399.6
AFTER TEST	B	398.4	316.8	---

NOTE: T - TOP HOLE DURING TEST
C - CENTER HOLE DURING TEST
B - BOTTOM HOLE DURING TEST

TABLE 6

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE
TESTS - BOLT INITIALLY TORQUED TO 35 IN-LBS

GROOV-PIN INSERTS

10-32, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	37.2	32.4	30.0
BEFORE TEST	C	100.8*	27.6	28.8
BEFORE TEST	B	28.8	31.2	61.2
AFTER TEST	T	---	39.6	---
AFTER TEST	C	92.4*	37.2	34.8
AFTER TEST	B	44.4	---	63.6
10-32, FACTORY INSTALLED				
BEFORE TEST	T	45.6	36.0	34.8
BEFORE TEST	C	33.6	31.2	24.0
BEFORE TEST	B	36.0	30.0	55.2
AFTER TEST	T	---	32.4	---
AFTER TEST	C	38.4	45.6	49.2
AFTER TEST	B	38.4	---	38.4

NOTE: T = TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

*Bolt was abnormally tight in the insert threads.

TABLE 7

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLT INITIALLY TORQUED TO 70 IN-LBS

GROOV-PIN INSERTS

1/4-28, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	58.8	61.2	56.4
BEFORE TEST	C	62.4	60.0	76.8
BEFORE TEST	B	66.0	66.0	61.2
AFTER TEST	T	---	---	82.8
AFTER TEST	C	81.6	51.6	---
AFTER TEST	B	57.6	56.4	62.4
1/4-28, FACTORY INSTALLED				
BEFORE TEST	T	52.8	62.8	67.2
BEFORE TEST	C	62.4	57.4	57.6
BEFORE TEST	B	60.0	60.0	62.4
AFTER TEST	T	73.2	78.0	76.8
AFTER TEST	C	---	76.8	68.4
AFTER TEST	B	64.8	---	---

NOTE: T = TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

TABLE 8

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLTS INITIALLY TORQUED TO 245 IN-LBS

GROOV-PIN INSERTS

3/8-24, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	184.8	183.6	176.4
BEFORE TEST	C	211.2	193.2	208.8
BEFORE TEST	B	188.4	163.2	211.2
AFTER TEST	T	---	121.2	252.0
AFTER TEST	C	297.6	410.4	291.6
AFTER TEST	B	291.6	---	---
3/8-24, FACTORY INSTALLED				
BEFORE TEST	T	178.8	187.2	195.6
BEFORE TEST	C	213.6	204.0	220.8
BEFORE TEST	B	175.2	195.6	206.4
AFTER TEST	T	312.0	---	295.2
AFTER TEST	C	---	321.6	334.8
AFTER TEST	B	345.6	344.4	---

NOTE: T - TOP HOLE DURING TEST
C - CENTER HOLE DURING TEST
B - BOTTOM HOLE DURING TEST

TABLE 9

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE
TESTS - BOLT INITIALLY TORQUED TO 35 IN-LBS

HELI-COIL INSERTS

10-32, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	31.2	31.2	32.4
BEFORE TEST	C	26.4	33.6	31.2
BEFORE TEST	B	28.8	36.0	33.6
AFTER TEST	T	43.2	---	51.6
AFTER TEST	C	---	42.0	45.6
AFTER TEST	B	43.2	46.8	---
10-32, FACTORY INSTALLED				
BEFORE TEST	T	33.6	60.0	33.6
BEFORE TEST	C	34.8	34.8	31.2
BEFORE TEST	B	33.6	36.0	31.2
AFTER TEST	T	37.2	---	---
AFTER TEST	C	---	34.8	39.6
AFTER TEST	B	48.0	45.6	39.6

NOTE: T = TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

TABLE 10

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLT INITIALLY TORQUED TO 70 IN-LBS

HELI-COIL INSERTS

1/4-28, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	60.0	61.2	70.8
BEFORE TEST	C	61.2	63.6	60.0
BEFORE TEST	B	62.4	63.6	62.4
AFTER TEST	T	93.6	93.6	94.8
AFTER TEST	C	---	91.2	93.6
AFTER TEST	B	105.6	---	---

1/4-28, FACTORY INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	50.4	66.0	62.4
BEFORE TEST	C	67.2	62.4	60.0
BEFORE TEST	B	52.8	58.8	64.8
AFTER TEST	T	---	60.0	81.6
AFTER TEST	C	93.6	---	85.2
AFTER TEST	B	93.6	86.4	---

NOTE: T = TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

TABLE 11

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLT INITIALLY TORQUED TO 245 IN-LBS

HELI-COIL INSERTS

3/8-24, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	188.4	204.0	187.2
BEFORE TEST	C	204.0	237.6	249.6
BEFORE TEST	B	295.6	297.6	235.2
AFTER TEST	T	336	327.6	---
AFTER TEST	C	368.4	314.4	343.2
AFTER TEST	B	---	---	356.4
3/8-24, FACTORY INSTALLED				
BEFORE TEST	T	206.4	208.8	339.6
BEFORE TEST	C	188.4	208.8	324.
BEFORE TEST	B	198.0	187.2	336.
AFTER TEST	T	296.4	288.0	345.6
AFTER TEST	C	337.2	345.6	---
AFTER TEST	B	---	---	338.4

NOTE: T - TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

TABLE 12

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLT INITIALLY TORQUED TO 35 IN-LBS

<u>LONG-LOK INSERTS</u>

<u>10-32, AFML INSTALLED</u>

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	32.4	32.4	30.0
BEFORE TEST	C	34.8	32.4	30.0
BEFORE TEST	B	33.6	33.6	36.0
AFTER TEST	T	38.4	33.6	34.8
AFTER TEST	C	---	---	---
AFTER TEST	B	32.4	38.4	38.4
<u>10-32, FACTORY INSTALLED</u>				
BEFORE TEST	T	31.2	34.8	55.2
BEFORE TEST	C	26.4	32.4	28.8
BEFORE TEST	B	30.0	33.6	34.8
AFTER TEST	T	---	---	60.6
AFTER TEST	C	36.0	37.2	40.8
AFTER TEST	B	23.6	38.4	---

NOTE: T = TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

TABLE 13

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLT INITIALLY TORQUED TO 70 IN-LBS

LONG-LOK INSERTS

1/4-28, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	64.8	56.4	62.4
BEFORE TEST	C	62.4	58.8	63.6
BEFORE TEST	B	62.4	58.8	63.6
AFTER TEST	T	48.0	---	58.8
AFTER TEST	C	57.6	68.4	66.0
AFTER TEST	B	---	61.2	---
1/4-28, FACTORY INSTALLED				
BEFORE TEST	T	60.0	64.8	60.0
BEFORE TEST	C	62.4	55.2	60.0
BEFORE TEST	B	58.8	60.0	57.6
AFTER TEST	T	48	---	---
AFTER TEST	C	---	61.2	51.6
AFTER TEST	B	62.4	62.4	67.2

NOTE T = TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

TABLE 14

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLTS INITIALLY TORQUED TO 245 IN-LBS

LONG-LOK INSERTS

3/8-24, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	180.0	176.4	202.8
BEFORE TEST	C	180.0	183.6	228.0
BEFORE TEST	B	190.8	192.0	188.4
AFTER TEST	T	---	---	355.2
AFTER TEST	C	184.8	360.0	273.6
AFTER TEST	B	106.8	273.6	---

3/8-24, FACTORY INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	202.8	178.8	199.2
BEFORE TEST	C	294.0	193.2	180.0
BEFORE TEST	B	213.6	242.4	180.0
AFTER TEST	T	259.2	314.4	279.6
AFTER TEST	C	351.6	297.6	262.8
AFTER TEST	B	---	---	---

NOTE: T - TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

TABLE 15

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLT INITIALLY TORQUED TO 35 IN-LBS

ROSAN INSERTS

10-32, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	28.8	26.4	30.0
BEFORE TEST	C	30.0	34.8	34.8
BEFORE TEST	B	30.0	30.0	32.4
AFTER TEST	T	34.8	33.6	32.4
AFTER TEST	C	---	36.0	---
AFTER TEST	B	33.6	---	27.6

10-32, FACTORY INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	32.4	34.8	36.0
BEFORE TEST	C	34.8	28.8	37.2
BEFORE TEST	B	33.6	31.2	33.6
AFTER TEST	T	26.4	34.8	33.6
AFTER TEST	C	28.8	24.0	31.2
AFTER TEST	B	---	---	---

NOTE: T = TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

TABLE 16

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLT INITIALLY TORQUED TO 70 IN-LBS

ROSAN INSERTS

1/4-28, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	46.8	44.4	43.2
BEFORE TEST	C	57.6	44.4	50.4
BEFORE TEST	B	54.0	45.6	51.6
AFTER TEST	T	73.2	69.6	---
AFTER TEST	C	4.8*	---	85.2
AFTER TEST	B	---	72.0	---
1/4-28, FACTORY INSTALLED				
BEFORE TEST	T	55.2	49.2	62.4
BEFORE TEST	C	62.4	74.4	58.8
BEFORE TEST	B	69.6	54.0	62.4
AFTER TEST	T	62.4	50.4	61.2
AFTER TEST	C	---	64.8	56.4
AFTER TEST	B	55.2	---	---

NOTE: T = TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

* Partial failure at center hole.

TABLE 17

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE
TESTS - BOLTS INITIALLY TORQUED TO 245 IN-LBS

ROSAN INSERTS

3/8-24, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	154.8	147.6	170.2
BEFORE TEST	C	166.8	200.4	177.6
BEFORE TEST	B	169.2	170.4	157.2
AFTER TEST	T	---	---	286.8
AFTER TEST	C	186	308.4	300
AFTER TEST	B	232.8	242.4	---
3/8-24, FACTORY INSTALLED				
BEFORE TEST	T	165.6	172.8	164.4
BEFORE TEST	C	165.6	172.8	164.4
BEFORE TEST	B	165.6	286.8	147.6
AFTER TEST	T	---	---	256.8
AFTER TEST	C	249.6	253.2	---
AFTER TEST	B	231.6	237.6	241.2

NOTE: T - TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

TABLE 18

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLT INITIALLY TORQUED TO 35 IN-LBS

TRIDAIR INSERTS

10-32, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	33.6	31.2	28.8
BEFORE TEST	C	30.0	31.6	32.4
BEFORE TEST	B	33.6	31.2	32.4
AFTER TEST	T	---	37.2	43.2
AFTER TEST	C	46.8	---	45.6
AFTER TEST	B	44.4	36.0	---

10-32, FACTORY INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	33.6	36.0	31.2
BEFORE TEST	C	34.8	27.6	31.2
BEFORE TEST	B	36.0	34.8	32.4
AFTER TEST	T	30.0	---	---
AFTER TEST	C	39.6	37.2	37.2
AFTER TEST	B	---	24.0	40.8

NOTE: T = TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

TABLE 19

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLT INITIALLY TORQUED TO 70 IN-LBS

TRIDAIR INSERTS

1/4-28, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	68.4	62.4	52.8
BEFORE TEST	C	63.6	61.2	61.2
BEFORE TEST	B	43.2	63.6	67.2
AFTER TEST	T	78.0	---	85.2
AFTER TEST	C	---	64.8	---
AFTER TEST	B	69.6	92.4	62.4
1/4-28, FACTORY INSTALLED				
BEFORE TEST	T	60.0	63.6	57.6
BEFORE TEST	C	61.2	61.2	60.0
BEFORE TEST	B	63.6	49.2	64.8
AFTER TEST	T	---	---	80.4
AFTER TEST	C	68.4	81.6	74.4
AFTER TEST	B	69.6	81.6	---

NOTE: T = TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

TABLE 20

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLTS INITIALLY TORQUED TO 245 IN-LBS

TRIDAIR INSERTS

3/8-24, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	174.0	178.8	186
BEFORE TEST	C	190.8	181.2	192
BEFORE TEST	B	194.4	199.2	188.4
AFTER TEST	T	339.6	---	---
AFTER TEST	C	---	331.2	320.4
AFTER TEST	B	285.6	352.8	373.2
3/8-24, FACTORY INSTALLED				
BEFORE TEST	T	188.4	192	189.6
BEFORE TEST	C	189.6	204	228
BEFORE TEST	B	220.8	206.4	207.6
AFTER TEST	T	302.4	213.6	367.2
AFTER TEST	C	---	235.2	---
AFTER TEST	B	258	---	327.6

NOTE: T - TOP HOLE DURING TEST
C - CENTER HOLE DURING TEST
B - BOTTOM HOLE DURING TEST

TABLE 21

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLT INITIALLY TORQUED TO 36 IN-LBS

TORKON INSERTS

10-32, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	31.2	30.0	31.2
BEFORE TEST	C	28.8	31.2	32.4
BEFORE TEST	B	28.8	28.8	31.2
AFTER TEST	T	39.6	31.2	33.6
AFTER TEST	C	46.8	30.0	34.8
AFTER TEST	B	----	----	----

10-32, FACTORY INSTALLED

	HOLE LOCATION	TEST 1	TEST 2	TEST 3
BEFORE TEST	T	26.4	26.4	26.4
BEFORE TEST	C	30.0	25.2	27.6
BEFORE TEST	B	26.4	27.6	27.6
AFTER TEST	T	27.6	31.2	32.4
AFTER TEST	C	----	----	----
AFTER TEST	B	28.8	30.0	39.6

NOTE: T = TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

TABLE 22

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLT INITIALLY TORQUED TO 70 IN-LBS

TORKON INSERTS

1/4-28, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	60.0	57.6	60.0
BEFORE TEST	C	58.8	60.0	64.8
BEFORE TEST	B	61.2	55.2	63.6
AFTER TEST	T	60.0	---	---
AFTER TEST	C	64.8	60.0	62.4
AFTER TEST	B	---	58.8	42.0

1/4-28, FACTORY INSTALLED

	HOLE LOCATION	TEST 1	TEST 2	TEST 3
BEFORE TEST	T	57.6	55.2	51.6
BEFORE TEST	C	52.8	52.8	42.0
BEFORE TEST	B	52.8	57.6	52.8
AFTER TEST	T	58.8	---	49.2
AFTER TEST	C	52.8	57.6	50.4
AFTER TEST	B	---	70.8	---

NOTE:
T = TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

TABLE 23

BREAKAWAY TORQUE BEFORE AND AFTER FATIGUE TESTS - BOLTS INITIALLY TORQUED TO 246 IN-LBS

TORKON INSERTS

3/8-24, AFML INSTALLED

	HOLE LOCATION	TORQUE IN-LBS. TEST 1	TEST 2	TEST 3
BEFORE TEST	T	196.8	201.6	180
BEFORE TEST	C	230.4	199.2	192
BEFORE TEST	B	336	178.8	200.4
AFTER TEST	T	---	340.8	230.8
AFTER TEST	C	284.4	231.6	266.4
AFTER TEST	B	236.8	---	---
3/8-24, FACTORY INSTALLED				
BEFORE TEST	T	177.6	177.6	184.8
BEFORE TEST	C	175.2	186	181.2
BEFORE TEST	B	182.4	177.6	193.2
AFTER TEST	T	---	207.6	264
AFTER TEST	C	248.4	---	228.0
AFTER TEST	B	236.4	246	---

NOTE: T - TOP HOLE DURING TEST
C = CENTER HOLE DURING TEST
B = BOTTOM HOLE DURING TEST

TABLE 24

THE AVERAGE BREAKAWAY BOLT TORQUE
BEFORE AND AFTER FATIGUE TESTS

INSERT MANUFACTURER	SIZE-10-32 BOLTS INITIALLY TORQUED TO 35 IN-LBS		SIZE-1/4-28 BOLTS INITIALLY TORQUED TO 70 IN-LBS		SIZE-3/8-24 BOLTS INITIALLY TORQUED TO 245 IN-LBS	
	BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
KAYNAR	29.2	29.5	56.1	54.5	198.2	299.7
ROSAN	32.2	31.4	55.2	67.4	173.3	252.1
HELI-COIL	34.0	43.1	61.7	89.4	216.3	328.6
TRIDAIR	32.4	38.5	60.2	75.7	199.9	308.9
LONG-LOK	33.4	38.4	60.6	59.9	200.2	276.6
TORKON	28.7	33.8	56.4	57.3	197.2	255.1
GROOV-PIN	35.3	46.2	61.7	69.2	194.3	300

Table 25

RESULTS OF FATIGUE TESTS OF 7075-T73 ALUMINUM ALLOY WITH 1/4-28 THREADED HOLES AND SMOOTH HOLES

SPEC. NO.	CONDITION OF HOLES	MAXIMUM STRESS KSI	CYCLES TO FAILURE
2-1	SMOOTH HOLES	32.0	34,900
2-2	.350" DIA.	32.0	43,100
2-3	"	32.0	27,600
AVERAGE			35,200
	THREADED WITH		
2-4	1/4-28 Tap for	32.0	31,700
2-5	Helical Coil	32.0	27,000
2-6	Insert	32.00	33,200
2-7	"	32.0	30,900
2-8	"	32.0	30,200
2-9	"	32.0	30,000
AVERAGE			30,500
	THREADED WITH		
2-10	1/4-28 TAP	32.0	27,300
2-11	"	32.0	33,200
2-12	"	32.0	35,200
2-13	"	32.0	27,900
2-14	"	32.0	29,200
2-15	"	32.0	29,600
AVERAGE			30,400

TABLE 26

RESULTS OF FATIGUE TESTS OF 7075-T73 ALUMINUM ALLOY WITH 1/4-28 THREADED INSERTS ONLY

SPEC. NO.	INSERT DATA NO-BOLT INSERT ONLY	MANUFACTURER	PART NR.	INSERT INSTALLED BY	MAX. STRESS	CYCLES TO FAILURE	COMMENTS FAILURE LOCATION
2-4	--	KAYNAR	K8000-4	AFML	32.0	24,300	Bottom
2-5	--	"	"	"	32.0	32,400	Top
2-6	--	"	"	"	32.0	31,100	Center
2-14	--	"	"	KAYNAR	32.0	27,400	Bottom
2-15	--	"	"	"	32.0	44,100	Center
2-16	--	"	"	"	32.0	35,000	Bottom
2-4	--	ROSAN	SR-2581	AFML	32.0	32,700	Top
2-5	--	"	"	"	32.0	33,500	Bottom
2-6	--	"	"	"	32.0	31,300	Top
2-13	--	"	"	ROSAN	32.0	50,300	Center
2-14	--	"	"	"	32.0	30,500	Center
2-15	--	"	"	"	32.0	50,800	Top
2-4	--	HELI-COIL	3591-4CNW-0375	AFML	32.0	30,000	Center
2-5	--	"	"	"	32.0	25,500	Bottom
2-6	--	"	"	"	32.0	35,900	Bottom
2-13	--	"	"	HELI-COIL	32.0	34,500	Top
2-14	--	"	"		32.0	32,100	Center
2-15	--	"	"	"	32.0	34,600	Center
2-4	--	TRIDAIR	TLF-4C-375W	AFML	32.0	41,400	Top
2-5	--	"		"	32.0	33,500	Bottom
2-6	--	"	"	"	32.0	31,500	Center
2-13	--	"	"	TRIDAIR	32.0	27,800	Top
2-14	--	"	"	"	32.0	38,300	Top
2-15	--	"	"	"	32.0	35,100	Bottom
2-4	--	LONG-LOK	T-048	AFML	32.0	28,600	Top
2-5	--	"	"	"	32.0	37,700	Bottom
2-6	--	"	"	"	32.0	30,200	Bottom
2-13	--	"	"	LONG-LOK	32.0	31,700	Center
2-14	--	"	"	"	32.0	29,500	Top
2-15	--	"	"	"	32.0	28,000	Center
2-4	--	TORKON	T1 1011-119	AFML	33.0	29,000	Bottom
2-5	--	"		"	33.0	28,200	Bottom
2-6	--	"	"	"	33.0	27,800	Top
2-13	--	"	"	TORKON	33.0	26,500	Center
2-14	--	"	"	"	33.0	24,100	Center
2-15	--	"	"	"	33.0	24,400	Bottom
2-7	--	GROOV-PIN	NM-25028-90	AFML	32.0	25,700	Top
2-8	--	"		"	32.0	29,500	Top
2-10	--	"	"	"	32.0	22,800	Bottom
2-13	--	"	"	GROOV-PIN	32.0	25,400	Center
2-14	--	"	"	"	32.0	29,300	Bottom
2-15	--	"	"	"	32.0	27,200	Center

TABLE 27

RESULTS OF FATIGUE TESTS OF 7075-T73 ALUMINUM ALLOY WITH HELI-COIL THREADED INSERT AND BOLT INSTALLED

SPEC. NO.	INSERTS INSTALLED BY	INSERT SIZE AND PART NUMBER	BOLT TORQUE IN-LBS.	7075-T73 PLATE — THICKNESS INCHES	LOADING STRESS PSI	CYCLES TO FAILURE	COMMENTS
							FREQUENCY 25 HZ
1-1	AFML		35	5/16	33,000	71,300	Failed at Center Hole
1-2	AFML		35	5/16	33,000	67,500	Failed at Top Hole
1-3	AFML	10-32	35	5/16	33,000	78,400	Failed at Bottom Hole
1-4	MFG	3591-3CNW	35	5/16	33,000	59,200	Failed at Center Hole
1-5	MFG		35	5/16	33,000	* 103,400	Failed at Top Hole
1-6	MFG		35	5/16	33,000	67,100	Failed at Top Hole
							FREQUENCY 25 HZ
2-1	AFML		70	1/2	32,000	43,400	Failed at Center Hole
2-2	AFML		70	1/2	32,000	46,400	Failed at Bottom Hole
2-3	AFML	1/4-28	70	1/2	32,000	58,900	Failed at Bottom Hole
2-16	MFG	3591-4CNW	70	1/2	32,000	43,500	Failed at Top Hole
2-17	MFG		70	1/2	32,000	53,800	Failed at Center Hole
2-18	MFG		70	1/2	32,000	49,500	Failed at Bottom Hole
							FREQUENCY 15 HZ
3-1	AFML		245	3/4	34,500	45,400	Failed at Bottom Hole
3-2	AFML		245	3/4	34,500	42,400	Failed at Bottom Hole
3-3	AFML	3/8-24	245	3/4	34,500	38,400	Failed at Top Hole
3-4	MFG	3591-6CNW	245	3/4	34,500	42,500	Failed at Bottom Hole
3-5	MFG		245	3/4	34,500	41,800	Failed at Bottom Hole
3-6	MFG		245	3/4	34,500	45,000	Failed at Center Hole

* NOT INCLUDED IN AVERAGE

TABLE 28

RESULTS OF FATIGUE TESTS OF 7075-T73 ALUMINUM ALLOY WITH TRIDAIR THREADED INSERT AND BOLT INSTALLED

SPEC. NO.	INSERTS INSTALLED BY	INSERT SIZE AND PART NUMBER	BOLT TORQUE IN-LBS.	7075-T73 PLATE — THICKNESS INCHES	LOADING STRESS PSI	CYCLES TO FAILURE	COMMENTS
							25 HZ
1-1	AFML		35	5/16	33,000	56,400	Failed at Top Hole
1-2	AFML		35	5/16	33,000	53,100	Failed at Center Hole
1-3	AFML	10-32	35	5/16	33,000	56,800	Failed at Bottom Hole
1-4	MFG	TLF-3C-0285	35	5/16	33,000	54,600	Failed at Bottom Hole
1-5	MFG		35	5/16	33,000	55,000	Failed at Top Hole
1-6	MFG		35	5/16	33,000	56,600	Failed at Top Hole
							25 HZ
2-1	AFML		70	1/2	32,000	45,900	Failed at Center Hole
2-2	AFML		70	1/2	32,000	45,300	Failed at Top Hole
2-3	AFML	1/4-28	70	1/2	32,000	47,100	Failed at Center Hole
2-16	MFG	TLF-4C-0375	70	1/2	32,000	37,400	Failed at Top Hole
2-17	MFG		70	1/2	32,000	52,800	Failed at Top Hole
2-18	MFG		70	1/2	32,000	44,300	Failed at Bottom Hole
							15 HZ
3-1	AFML		245	3/4	34,500	31,700	Failed at Center Hole
3-2	AFML		245	3/4	34,500	29,600	Failed at Top Hole
3-3	AFML	3/8-24	245	3/4	34,500	30,200	Failed at Top Hole
3-4	MFG	TLF-6C-0562	245	3/4	34,500	38,400	Failed at Center Hole
3-5	MFG		245	3/4	34,500	*124,000	Failed at Bottom Hole
3-6	MFG		245	3/4	34,500	43,900	Failed at Center Hole

* NOT INCLUDED IN AVERAGE

TABLE 29

RESULTS OF FATIGUE TESTS OF 7075-T73 ALUMINUM ALLOY
WITH ROSAN THREADED INSERT AND BOLT INSTALLED

SPEC. NO.	INSERTS INSTALLED BY	INSERT SIZE AND PART NUMBER	BOLT TORQUE IN-LBS.	7075-T73 PLATE — THICKNESS INCHES	LOADING STRESS PSI	CYCLES TO FAILURE	COMMENTS
							25 HZ
1-1	AFML		35	5/16	33,000	54,900	Failed at Center Hole
1-2	AFML		35	5/16	33,000	41,500	Failed at Bottom Hole
1-3	AFML	10-32	35	5/16	33,000	41,400	Failed at Center Hole
1-4	MFG	SR-192L	35	5/16	33,000	43,100	Failed at Bottom Hole
1-5	MFG		35	5/16	33,000	47,700	Failed at Top Hole
1-6	MFG		35	5/16	33,000	37,900	Failed at Bottom Hole
							25 HZ
2-1	AFML		70	1/2	32,000	43,200	Failed at Bottom Hole & Partial at Ctr.
2-2	AFML		70	1/2	32,000	39,000	Failed at Center Hole
2-3	AFML	1/4-28	70	1/2	32,000	61,200	Failed at Bottom Hole
2-16	MFG	SR-258L	70	1/2	32,000	48,100	Failed at Center Hole
2-17	MFG		70	1/2	32,000	36,900	Failed at Bottom Hole
2-18	MFG		70	1/2	32,000	50,200	Failed at Bottom Hole
							15 HZ
3-1	AFML		245	3/4	34,500	33,700	Failed at Top Hole
3-2	AFML		245	3/4	34,500	32,400	Failed at Top Hole
3-3	AFML	3/8-24	245	3/4	34,500	42,400	Failed at Bottom Hole
3-4	MFG	SR-374L	245	3/4	34,500	49,700	Failed at Top Hole
3-5	MFG		245	3/4	34,500	44,700	Failed at Top Hole
3-6	MFG		245	3/4	34,500	40,800	Failed at Center Hole

TABLE 30

RESULTS OF FATIGUE TESTS OF 7075-T73 ALUMINUM ALLOY WITH KAYNAR THREADED INSERT AND BOLT INSTALLED

SPEC. NO.	INSERTS INSTALLED BY	INSERT SIZE AND PART NUMBER	BOLT TORQUE IN-LBS.	7075-T73 PLATE — THICKNESS INCHES	LOADING STRESS PSI	CYCLES TO FAILURE	COMMENTS
							25 HZ
1-1	AFML		35	5/16	33,000	46,500	Failed at Center Hole
1-2	AFML		35	5/16	33,000	48,600	Failed at Top Hole
1-3	AFML	10-32	35	5/16	33,000	53,500	Failed at Center Hole
1-4	MFG	K8000-3	35	5/16	33,000	50,800	Failed at Top Hole
1-5	MFG		35	5/16	33,000	39,100	Failed at Bottom Hole
1-6	MFG		35	5/16	33,000	38,500	Failed at Bottom Hole
							25 HZ
2-1	AFML		70	1/2	32,000	49,500	Failed at Bottom Hole
2-2	AFML		70	1/2	32,000	39,800	Failed at Center Hole
2-3	AFML	1/4-28	70	1/2	32,000	33,600	Failed at Center Hole
2-16	MFG	K8000-4	70	1/2	32,000	43,600	Failed at Bottom Hole
2-17	MFG		70	1/2	32,000	33,000	Failed at Top Hole
2-18	MFG		70	1/2	32,000	45,500	Failed at Top Hole
							15 HZ
3-1	AFML		245	3/4	34,500	38,500	Failed at Top Hole
3-2	AFML		245	3/4	34,500	43,000	Failed at Bottom Hole
3-3	AFML	3/8-24	245	3/4	34,500	47,200	Failed at Center Hole
3-4	MFG	K8000-6	245	3/4	34,500	53,900	Failed at Top Hole
3-5	MFG		245	3/4	34,500	49,500	Failed at Top Hole
3-6	MFG		245	3/4	34,500	35,800	Failed at Bottom Hole

TABLE 31

RESULTS OF FATIGUE TESTS OF 7075-T73 ALUMINUM ALLOY
WITH LONG-LOK THREADED INSERT AND BOLT INSTALLED

SPEC. NO.	INSERTS INSTALLED BY	INSERT SIZE AND PART NUMBER	BOLT TORQUE IN-LBS.	7075-T73 PLATE — THICKNESS INCHES	LOADING STRESS PSI	CYCLES TO FAILURE	COMMENTS
							25 HZ
1-1	AFML		35	5/16	33,000	48,800	Failed at Center Hole
1-2	AFML		35	5/16	33,000	53,400	Failed at Center Hole
1-3	AFML	10-32	35	5/16	33,000	35,900	Failed at Center Hole
1-4	MFG	T02P59	35	5/16	33,000	53,200	Failed at Top Hole
1-5	MFG		35	5/16	33,000	40,900	Failed at Top Hole
1-6	MFG		35	5/16	33,000	56,000	Failed at Bottom Hole
							25 HZ
2-1	AFML		70	1/2	32,000	33,900	Failed at Bottom Hole
2-2	AFML		70	1/2	32,000	52,800	Failed at Top Hole
2-3	AFML	1/4-28	70	1/2	32,000	52,100	Failed at Bottom Hole
2-16	MFG	T048P59	70	1/2	32,000	41,800	Failed at Center Hole
2-17	MFG		70	1/2	32,000	34,800	Failed at Top Hole
2-18	MFG		70	1/2	32,000	33,700	Failed at Top Hole
							15 HZ
3-1	AFML		245	3/4	34,500	*86,900	Failed at Top Hole
3-2	AFML		245	3/4	34,500	33,600	Failed at Top Hole
3-3	AFML	3/8-24	245	3/4	34,500	28,400	Failed at Bottom Hole
3-4	MFG	T-64P59	245	3/4	34,500	30,700	Failed at Bottom Hole
3-5	MFG		245	3/4	34,500	22,300	Failed at Bottom Hole
3-6	MFG		245	3/4	34,500	26,400	Failed at Bottom Hole

* NOT INCLUDED IN AVERAGE

TABLE 32

RESULTS OF FATIGUE TESTS OF 7075-T73 ALUMINUM ALLOY WITH TORKON THREADED INSERT AND BOLT INSTALLED

SPEC. NO.	INSERTS INSTALLED BY	INSERT SIZE AND PART NUMBER	BOLT TORQUE IN-LBS.	7075-T73 PLATE — THICKNESS INCHES	LOADING STRESS PSI	CYCLES TO FAILURE	COMMENTS
							25 HZ
1-1	AFML		35	5/16	33.000	35.400	Failed at Bottom Hole
1-2	AFML		35	5/16	33.000	35.200	Failed at Bottom Hole
1-3	AFML	10-32	35	5/16	33,000	35.600	Failed at Bottom Hole
1-4	MFG	TI-1011-117	35	5/16	33,000	31.600	Failed at Center Hole
1-5	MFG		35	5/16	33,000	25,300	Failed at Center Hole
1-6	MFG		35	5/16	33,000	24,400	Failed at Center Hole
							25 HZ
2-1	AFML		70	1/2	32.000	37.600	Failed at Bottom Hole
2-2	AFML		70	1/2	32,000	38.500	Failed at Top Hole
2-3	AFML	1/4-28	70	1/2	32.000	35.900	Failed at Top Hole
2-16	MFG	T1-1011-119	70	1/2	32.000	35.900	Failed at Bottom Hole
2-17	MFG		70	1/2	32,000	37.300	Failed at Top Hole
2-18	MFG		70	1/2	32.000	37.500	Failed at Bottom Hole
							15 HZ
3-1	AFML		245	3/4	34,500	37.400	Failed at Top Hole
3-2	AFML		245	3/4	34,500	36.400	Failed at Bottom Hole
3-3	AFML	3/8-24	245	3/4	34,500	42,300	Failed at Bottom Hole
3-4	MFG	T1-1011-223	245	3/4	34,500	28,900	Failed at Top Hole
3-5	MFG		245	3/4	34.500	28.500	Failed at Center Hole
3-6	MFG		245	3/4	34.500	36.200	Failed at Bottom Hole

TABLE 33

RESULTS OF FATIGUE TESTS OF 7075-T73 ALUMINUM ALLOY WITH GROOV-PIN THREADED INSERT AND BOLT INSTALLED

SPEC. NO.	INSERTS INSTALLED BY	INSERT SIZE AND PART NUMBER	BOLT TORQUE IN-LBS.	7075-T73 PLATE THICKNESS INCHES	LOADING STRESS PSI	CYCLES TO FAILURE	COMMENTS
							25 HZ
1-1	AFML		35	5/16	33,000	69,400	Failed at Top Hole
1-2	AFML		35	5/16	33,000	42,800	Failed at Bottom Hole
1-3	AFML	10-32	35	5/16	33,000	68,600	Failed at Top Hole
1-4	MFG	NM-19032-90	35	5/16	33,000	49,800	Failed at Top Hole
1-5	MFG		35	5/16	33,000	79,200	Failed at Bottom Hole
1-6	MFG		35	5/16	33,000	50,900	Failed at Top Hole
							25 HZ
2-1	AFML		70	1/2	32,000	40,700	Failed at Top Hole
2-2	AFML		70	1/2	32,000	29,100	Failed at Top Hole
2-3	AFML	1/4-28	70	1/2	32,000	39,000	Failed at Center Hole
2-16	MFG	NM-25028-90	70	1/2	32,000	45,400	Failed at Center Hole
2-17	MFG		70	1/2	32,000	29,700	Failed at Bottom Hole
2-18	MFG		70	1/2	32,000	32,900	Failed at Bottom Hole
							15 HZ
3-1	AFML		245	3/4	34,500	27,200	Failed at Top Hole
3-2	AFML		245	3/4	34,500	33,700	Failed at Bottom Hole
3-3	AFML	3/8-24	245	3/4	34,500	35,800	Failed at Bottom Hole
3-4	MFG	NM-37524-90	245	3/4	34,500	48,800	Failed at Center Hole
3-5	MFG		245	3/4	34,500	48,500	Failed at Top Hole
3-6	MFG		245	3/4	34,500	48,700	Failed at Bottom Hole

TABLE 34

PERCENTAGE INCREASE OR DECREASE OF THE FATIGUE LIFE OF 7075-T73 ALLOY WITH THREADED HOLES WHEN 1/4-28 INSERTS ARE ADDED OR WHEN INSERTS AND BOLTS ARE ADDED

INSERT MANUFACTURER	7075-T73 ALLOY WITH INSERT	7075-T73 ALLOY WITH INSERT AND BOLT
HELI-COIL	5.2 %	61.4%
TRIDAIR	13.4%	49.0%
ROSAN	25.6%	52.7%
KAYNAR	6.5%	34.3%
LONG-LOK	2.4%	39.8%
TORKON	-10.0% DECREASE	22.0%
GROOV-PIN	-12.3% DECREASE	18.8%

TABLE 35

ROOM TEMPERATURE AXIAL STRENGTH TESTS

INSERTS INSTALLED BY	INSERT SIZE	INSERT MANUFACTURER AND PART NUMBER						
		HELI-COIL 3591-6CN LOAD-LBS	TRIDAIR TFL-6C-0562 LOAD-LBS	ROSAN SR-374L LOAD-LBS	KAYNAR K8000-6 LOAD-LBS	LONG-LOK T-064-P59 LOAD-LBS	TORKON TI 1011-223 LOAD-LBS	GROOV-PIN NM37524-90 LOAD-LBS
AFML	(1) 3/8-24	19,500	19,600	17,200	16,400	22,300	20,200	20,800
AFML	3/8-24	19,500	19,900	20,800	16,200	21,000	20,250	18,400
AFML	3/8-24	19,350	19,100	20,000	16,600	21,000	21,700	15,800
A V E R A G E		19,450	19,533	19,333	16,400	21,433	20,716	18,333
MFG	3/8-24	19,650	20,000	20,200	13,600	21,000	25,000	20,100
MFG	3/8-24	19,400	20,200	20,400	14,900	21,000	25,000*	20,500
MFG	3/8-24	19,300	19,100	19,000	13,700	21,500	24,300	20,200
A V E R A G E		19,450	19,766	19,866	14,066	21,166	24,766	20,266
	(2)	3591-4CN	TFL-4C-0375	SR-258L	K8000-4	T-048P59	TI 1011-119	NM-25028-90
AFML	1/4-28	8,600	9,800	9,520	8,310	10,300*	8,280	8,000
AFML	1/4-28	8,310	9,900*	9,600	8,100	10,000	7,700	9,500
AFML	1/4-28	8,280	9,300	9,200	7,650	10,100	9,100	8,100
A V E R A G E		8,396	9,666	9,440	8,020	10,133	8,360	8,533
MFG	1/4-28	8,500	9,400	10,000*	7,900	10,500*	9,600	8,100
MFG	1/4-28	8,720	9,900*	10,400*	7,600	9,800	7,400	8,450
MFG	1/4-28	8,780	9,800*	9,800*	7,960	10,000	7,800	9,700
A V E R A G E		8,666	9,700	10,066	7,820	10,100	8,266	8,750

* DENOTES BOLT FAILURE (BOLT FAILURE LOAD INCLUDED IN AVERAGE)

TABLE 35

ROOM TEMPERATURE AXIAL STRENGTH TESTS (CONTINUED)

INSERTS INSTALLED BY	INSERT SIZE	INSERT MANUFACTURER AND PART NUMBER						
		HELI-COIL 0285-3CN LOAD-LBS	TRIDAIR TLF-3C-0285 LOAD-LBS	ROSAN SR-192L LOAD-LBS	KAYNAR K8000-3 LOAD-LBS	LONG-LOK T-02P59 LOAD-LBS	TORKON Ti 1011-117 LOAD-LBS	GROOV-PIN NM-19032-90 LOAD-LBS
AFML	10-32	4,750	4,520	4,500	4,800	5,000*	4,700	4,540
AFML	10-32	4,580	4,900	5,080*	4,000	4,720	5,000*	4,740
AFML	10-32	4,530	4,600	4,700	4,000	5,000*	4,620	4,140
AVERAGE		4,620	4,673	4,760	4,266	4,906	4,773	4,473
MFG	10-32	4,650	4,900	4,820*	5,000*	4,060*	4,680	5,900*
MFG	10-32	4,400	4,740	4,700	5,000*	4,480	5,240*	5,000*
MFG	10-32	4,320	4,800	4,200	5,020*	4,960*	4,600	4,780
AVERAGE		4,456	4,813	4,573	5,006	4,720	4,840	5,226

* DENOTES BOLT FAILURE

1 - Bolt Part No. BM3306-6-H-11 Steel

2 - Bolt Part No. BM9022-4-36

3 - Bolt Part No. 55132-3-30A Steel

TABLE 36

PULL OUT TENSILE STRENGTH AVERAGES OF INSERTS INSTALLED IN 7075-T73 ALUMINUM

THREAD SIZE	MANUFACTURER	INSERT TYPE AND LENGTH-IN	INSERT TENSILE STRENGTH-LBS. AVERAGE
		(1)	
10-32	Heli-Coil Wire Heli-Coil Products	0.285	4,538
10-32	Helical Coil Wire Tridair Inc.	0.285	4,743
10-32	Thin Wall Bushing Kaynar	0.300	4,636
10-32	Thin Wall Bushing Rosan	0.290	4,666
10-32	Thin Solid Wall Bushings Long-Lok	0.290	4,813
10-32	Thin Solid Wall Bushings Torkon	0.290	4,806
10-32	Self-Tapping Bushing Groov-Pin	0.296	4,849
1/4-28	Helical Coil Wire Heli-Coil Products	0.375	8,531
1/4-28	Helical Coil Wire Tridair, Inc.	0.375	9,683
1/4-28	Thin Wall Bushing Kaynar	0.390	7,920
1/4-28	Thin Wall Bushing Rosan	0.380	9,753
1/4-28	Thin Solid Wall Bushing Long-Lok	0.380	10,116
1/4-28	Thin Solid Wall Bushing Torkon	0.380	8313
1/4-28	Self-Tapping Bushing Groov-Pin	0.375	8,641

(1) Insert Lengths Are Taken From Manufacturers Specification

TABLE 36

PULL OUT TENSILE STRENGTH AVERAGES OF INSERTS INSTALLED IN 7075-T73 ALUMINUM (CONTINUED)

THREAD SIZE	MANUFACTURER	INSERT TYPE AND INSERT LENGTH-IN. (1)	TENSILE STRENGTH-LBS. AVERAGE
3/8-24	Helical Coil Wire Heli-Coil Products	0.562	19,450
3/8-24	Helical Coil Wire Tridair	0.562	19,650
3/8-24	Thin Wall Bushing Kaynar	0.570	15,233
3/8-24	Thin Wall Bushing Rosan	0.560	19,600
3/8-24	Thin Solid Wall Bushing Long-Lok	0.560	21,300
3/8-24	Thin Solid Wall Bushing Torkon	0.560	22,290
3/8-24	Self-Tapping Bushing Groov-Pin	0.562	19,300

(1) Insert Lengths Are Taken From Manufacturers Specification

TABLE 37

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Heli-Coil Products
INSERT TYPE & SIZE - Screw Locking CRES-3591-3CNW - 10-32
INSERT COATING - None Used
BOLT - NAS 1303-3
INSERT MATERIAL: CRES 18-8

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	9/7	8/7	7/7	9.5/8	8.5/7.5	9/8
2	8/7.5	7.5/7	7/7	7/6.5	7.5/7.5	8/8
3	7/7	6/6	6/5	7/7	7/7	8/7.5
4	6/7	6/5.5	6/5	6.5/6.5	7/6.5	7/7.5
5	6/6	5/5	5/5	5.5/5	6/7	6/7
6	5.5/5	5/5	5/5	6.5/6	5.5/5	7/7
7	5/5	5/5	6/5	6/5.5	6/6	6/7
8	5/5	6/5.5	5/5	6.5/6	6/6	5/5
9	5/5	5/5	7/5	6/5	6/6	5/5
10	6/5.5	5/5	6/5	6/5	6/6	6/6.5
11	6/5	5/5	6/5	5.5/5	5/5	5.5/5
12	5/5	5/5	5/6	5.5/5	5.5/5	6/6
13	5.5/5	5/5	6/5	5.5/5	5/5	6/6
14	5/5	5/5	5/5	5.5/5	6.5/5	5.5/5
15	5/5	5/5	5/5	5.5/5	6/5	5.5/5

NOTE: Test in accordance with MIL-N-25027

TABLE 38

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Tridair Industries
INSERT TYPE & SIZE - Coil Lock 18-8-TLF-3C-0285 10-32
INSERT COATING - Dry Film Lubricant
BOLT - NAS 1303-3
INSERT MATERIAL: CRES 18-8

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	5/5	3.5/3.5	3/2	5/5	1.5/1.5	5.5/5
2	2/2	4/4	3/2	5/5	1.5/1.5	5/5
3	1/1	4/4	2/2	5/4	1/1	5/5
4	1/1	1.5/1.5	2/2	5/4	1/1	4/4
5	1/1	1/1	2/2	5/4.5	1/1	4/4
6	1/1	No Torque Could Be Measured. Could Screw Bolt All The Way Thru Insert With Fingers	2/2	4.5/4.5	1/1	4/4
7	1/1		2/2	4.5/4.5	1/1	4/4.5
8	1/1		1.5/1.5	4.5/4.5	1/1	4/4
9	1/1		1.5/2	4.5/5	1/1	4/4
10	1/1		2/2	4.5/5	1/1	4/4
11	1/1		2/1	4.5/5	1/1	4/4
12	1/1		1.5/1	4.5/5	1/1	4/4
13	1/1		1.5/1	4.5/5	1/1	4/3.5
14	1/1		1.5/1	4.5/5	1/1	4/3.5
15	1/1		1/1	4.5/5	1/1	4/3.5

TABLE 39

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Long-Lok Corporation
INSERT TYPE & SIZE - T-Sert (T02P39) 10-32
INSERT COATING - Dry Film Lubricant
BOLT - NAS 1303-3
INSERT MATERIAL: CRES 18-8

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	2.5/2	4/4	4/4	4.5/4	5/5	5/5
2	2.5/2	3/3	4/3.5	4.5/4	4/4	4.5/4.5
3	2/2	3/3	3/3	3/3	4/4	4.5/4.5
4	2.5/2	3/3	3/3	3/3	4/4.5	4/4
5	2.5/2.5	3/3	3/3	3/3	4/4	4/4
6	2.5/2.5	3/3	3/3	3/3	4/4	3.5/3.5
7	2.5/2.5	3/3	3/3	3/3	4/4	3.5/3.5
8	2.5/2.5	3/2.5	3/3	3/3	4/4	3.5/3.5
9	2.5/2	3/2.5	3/3	3/3	3.5/3.5	3.5/3.5
10	2.5/[illegible]	3/2.5	2.5/2.5	2.5/2.5	3.5/3.5	3.5/3.5
11	2.5/2	3/2.5	2.5/2.5	2.5/2.5	3.5/3.5	3/3.5
12	2.5/2	3/2.5	2.5/2.5	2.5/2.5	4/4	3/3.5
13	2/2	3/2.5	2.5/2.5	2.5/2.5	4/4	3/3.5
14	2/2	3/2.5	2.5/2.5	2.5/2.5	4/4	3/3.5
15	2/2	3/2.5	2.5/2.5	2.5/2.5	3.5/3.5	3/3.5

TABLE 40

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Torkon Fastener Corporation
INSERT TYPE & SIZE - Threadline (Ti 1011-117) 10-32
INSERT COATING -
BOLT - NAS-1303-3
INSERT MATERIAL: CRES 18-8

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	7/7	6.5/7	8/7	6/5	8/8	6/6
2	6/6	5/6	6/6	6/5	7/7	6/6
3	6/6	5/5	6/6	6/5	6/6	4/4
4	6/7	7/7	6/7	4/4	6/6	4/4
5	5.5/6	6/6.5	6.5/6.5	4/4	6/6	4/3
6	5.5/6	5.5/5.5	6.5/7	4/4.5	5/6	3.5/3
7	5.5/5.5	5/5.5	6/6.5	4/4	5/5	4/3.5
8	5/5	5/5	7/7	4/4	5/5	4/3.5
9	5.5/5	5/5	6.5/7	4/4	5/5	3.5/3
10	5.5/5	5/5	7/7	4/4	5/5	3/3
11	5/5	5/5	6.5/6.5	4/4	5/5	3/3
12	5/5	4/4	6.5/7	4/4	5/4	2.5/2.5
13	5/5	4/4	5.5/5	3/4	5/5	2.5/2.5
14	5/5	4/4	6/6	3/4	4/4	2.5/2.5
15	5/5	3/3	6/6	3/4	4/4	2.5/2.5

TABLE 41

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Rosan
INSERT TYPE & SIZE - Slim Sert (SR-192L) 10-32
INSERT COATING - Dry Film Lubricant
BOLT - NAS 1303-3
INSERT MATERIAL: 17-4 PH Stainless Steel

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	9/7.5	14/12	9/8	15/13.5	10/8	16/15
2	10/10	15/15	6/5	17/14	10/8	16/16
3	7/7	13.5/12.5	6/5	15/14	9.5/8	15/14.5
4	8.5/8	11.5/11	5.5/5	13.5/12.5	7/6	14/12.5
5	7/8	10/10	5/4.5	12.5/11	6.5/6	12.5/11.5
6	6/7	10/9	5/5	11.5/11	6.5/6	9/9
7	6/5	9/7	5/4	11/10	5/5	10/9
8	6/5	9/8	5/4	11/10	6.5/5	11/10
9	5/5	9/8	5/4	10/9.5	5/5	11/9
10	6/6	8.5/8	5/4.5	10/10	5/5	9/7
11	6.5/5	8.5/5	4.5/4	11/10	6/5.5	8/7.5
12	5/5	10/9	4/4	10.5/10	6/5.5	8/8.5
13	6/6	8/6	4/4	11/10	5/5	8/8.5
14	6/6	8/8	4/3.5	11/10	5.5/5	8.5/8
15	6/6	8/8	4/3.5	10.5/10	5/5	8/7

TABLE 42

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Groov-Pin Corporation
INSERT TYPE & SIZE - Tap'Lok (NM 19032-90) 10-32 NYLOK
INSERT COATING -
BOLT - NAS-1303-3
INSERT MATERIAL: Hardened Stainless Steel

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	10/8	9/8	9/7	9/8	12/12	12/8
2	10/8.5	8/7	6/6	7/7	11/9	9/6
3	7/7	6/6	6/6	7/7	9/8	8/8
4	7/7	6/6	6/5.5	6/7	7/7	7/7
5	7/7	6/6	5/5	6/7	7/7	8/8
6	6/6	5.5/5.5	5/5	6/6	7/7	7/7
7	6.5/6.5	5/5	4.5/5	6/6	7/7	6/6
8	6/6	5/4	4.5/5	5.5/6	6.5/6.5	6/5
9	6/6	4.5/4.5	4/5	6/6	7/7	6/6
10	5/5	4/4.5	4/5	5.5/6	7/7	6/6
11	5/5	4/4.5	5/5	5.5/6	7/7	6/5.5
12	5/5	4.5/4.5	4/4	6/6	7/7	5.5/5.5
13	5/5	4.5/4.5	4/4	6/6	7/7	5.5/5.5
14	5/5	4/4	4/4	6/6	7/7	5.5/5.5
15	5/5	4/4	4/4	6/6	7/7	5.5/5.5

TABLE 43

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Kaynar
INSERT TYPE & SIZE - Thin Wall Self Locking (K8000-3) 10-32
INSERT COATING - Cadmium Plated & Kaylube Moly-disulfide Dry Film Lube.
BOLT - NAS-1303-3
INSERT MATERIAL: Alloy Steel, Heat Treated

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	8.4/9.6	8.4/7	6.0/5.5			
2	8.4/8.0	8.5/7	6.0/5.5			
3	6.0/6.0	8.0/7	6.0/5.0			
4	6.0/6.0	8.0/7	6.0/5.5			
5	6.0/6.0	8.0/7	5.5/5.0			
6	6.0/5.5	7.5/7	5.5/5.0			
7	5.5/5.5	7.5/7	5.0/5.0			
8	5.5/6.0	7.0/6.5	5.0/5.0			
9	6.0/6.0	7.0/6.5	5.0/5.0			
10	5.5/5.0	7.0/6.0	5.0/4.8			
11	5.5/5.0	7.0/6.0	5.0/4.8			
12	5.5/5.0	7.0/6.0	5.0/4.8			
13	5.4/5.0	7.0/6.0	5.0/4.5			
14	5.4/5.0	7.0/6.0	5.0/4.5			
15	5.4/5.0	7.0/6.0	5.0/4.5			

TABLE 44

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Heli-Coil Products
INSERT TYPE & SIZE - Screw Locking, CRES-3591-4CNW - 1/4-28
INSERT COATING - None Used
BOLT - NAS-1304-5

INSERT MATERIAL: CRES 18-8

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	23/20	20/20	22/19	22/20	24/20	22/18
2	21/20	19/19	17/17	20/18	20/20	16/16
3	21/20	18/18	17/16	16/16	20/22	16/14
4	20/19	20/18	17/16	16/15	20/18	14/14
5	18/18	18/17	16/15	16/14	18/18	12/11
6	18/16	16/16	16/16	14/14	16/16	12/11
7	15/15	16/16	16/16	14/15	18/17	12/11
8	15/15	17/16	15/15	15/15	16/16	12/11
9	15/14	17/16	15/15	15/15	16/16	12/11
10	15/15	16/16	13/12	14/14	16/16	12/11
11	14/14	17/16	13/12	14/15	16/17	12/11
12	14/14	16/16	13/13	14/14	17/17	12/11
13	14/14	16/16	13/12	14/14	17/16	12/11
14	14/14	15/14	13/12	13/13	15/14	12/11
15	14/14	15/14	13/12	13/13	15/14	12/11

TABLE 45

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Tridair Industries
INSERT TYPE & SIZE - Coil Lock - 18-8-TLF-4C-0375 - 1/4-28
INSERT COATING - Dry Film Lubricant
BOLT - NAS-1304-5
INSERT MATERIAL: CRES 18-8

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	24/22	20/18	22/22	24/24	23/22	20/20
2	24/23	20/18	21/21	24/24	23/22	20/19
3	24/23	20/18	21/21	23/23	22/22	19/19
4	24/23	20/18	20/21	23/22	22/22	19/18
5	24/23	20/18	20/20	22/22	22/21	19/18
6	24/23	20/18	20/20	22/21	20/20	18/18
7	21/21	20/18	20/20	21/20	20/20	18/19
8	22/22	20/18	19/19	21/21	20/20	18/17
9	22/22	20/18	19/19	21/21	20/20	18/18
10	22/22	20/18	19/20	21/21	20/19	17/18
11	22/22	20/18	20/20	20/20	18/17	18/19
12	22/22	20/18	19/20	20/21	18/19	18/18
13	22/22	20/18	19/19	20/20	18/18	18/18
14	22/22	20/18	19/19	20/20	18/18	18/17
15	22/22	20/18	19/19	20/20	18/18	18/18

TABLE 46

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Long-Lok Corporation
INSERT TYPE & SIZE - T-Sert (T048P59) 1/4-28
INSERT COATING - Dry Film Lubricant
BOLT - NAS-1304-5
INSERT MATERIAL: CRES 18-8

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	4/2	2/2	3/4	6/6	8/8	5/5
2	2/3	2/2	3/3	6/5	7/7	5/5
3	2/2	2/2	4/3	6/5	6/7	5/5
4	2/2	2/2	3/3	6/6	6/6	4/4
5	2/2	2/2	3/3	6/6	6/6	4/5
6	2/2	2/2	2/3	6/6	6/6	4/5
7	2/2	2/2	2/2	6/5	6/6	4/4
8	2/2	2/2	2/2	6/5	6/6	4/4
9	2/2	2/2	2/2	6/5	6/6	4/4
10	2/2	2/2	2/2	6/5	6/6	4/4
11	2/2	2/2	2/2	5/5	6/6	4/4
12	2/2	2/2	2/2	5/5	6/6	4/4
13	2/2	2/2	2/2	5/5	6/6	4/4
14	2/2	2/2	2/2	5/5	6/6	4/3
15	2/2	2/2	2/2	5/5	6/6	4/3

TABLE 47

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Torkon Fastener Corporation
INSERT TYPE & SIZE - Threadline (Ti 1011-119) 1/4-28
INSERT COATING -
BOLT - NAS-1304-5
INSERT MATERIAL: CRES 18-8

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	20/20	28/24	25/25	30/28	25/23	27/25
2	18/18	20/19	25/24	25/23	20/20	24/23
3	18/17	20/19	24/24	19/18	19/19	20/20
4	17/16	20/20	24/23	15/14	17/18	19/19
5	17/16	18/16	23/23	15/14	17/17	19/19
6	17/16	16/15	20/22	16/14	16/16	17/17
7	17/16	15/15	16/15	13/12	16/16	17/16
8	17/15	15/15	16/16	13/12	16/16	16/16
9	15/15	15/14	15/15	13/12	16/15	16/16
10	15/15	15/15	15/14	13/12	15/14	15/15
11	15/15	14/14	13/14	14/12	14/14	13/13
12	14/15	14/14	14/13	13/12	14/14	13/13
13	14/15	14/14	14/13	13/12	14/14	13/13
14	14/15	14/14	14/13	13/12	14/14	13/13
15	15/15	14/14	14/13	13/12	14/14	13/13

TABLE 48

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Kaynar
INSERT TYPE & SIZE - Thin Wall Self-Locking (K8000-4) 1/4-28
INSERT COATING - Cadmium Plated & Kaylube Moly-disulfide Dry Film Lube.
BOLT - NAS-1304-5
INSERT MATERIAL: Alloy Steel, Heat Treated

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	24/24	24/23	25/23	30/30	26/26	28/25
2	20/20	18/20	23/21	28/28	24/24	26/24
3	19/18	19/19	20/20	28/28	24/24	25/23
4	19/18	19/20	20/19	28/28	22/22	22/22
5	19/18	18/19	18/18	28/28	22/22	22/21
6	19/18	18/20	18/18	26/26	22/23	22/20
7	19/18	18/19	18/18	26/26	22/23	22/20
8	19/18	18/19	19/18	26/26	22/23	21/21
9	19/18	19/19	18/18	26/26	22/22	21/21
10	19/18	18/19	18/17	26/26	22/22	20/20
11	19/18	18/19	17/18	24/24	22/21	20/20
12	19/18	18/19	17/17	24/24	22/21	20/20
13	19/18	18/19	17/18	24/24	20/20	20/19
14	19/18	18/19	17/17	24/24	20/20	20/20
15	19/18	18/19	17/17	24/24	20/20	20/19

TABLE 49

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Rosan
INSERT TYPE & SIZE - Slim Sert (SR 258L) 1/4-28
INSERT COATING - Dry Film Lubricant
BOLT - NAS 1304-5
INSERT MATERIAL: 17-4 PH Stainless Steel

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	28/28	30/29	28/28	30/26	30/26	29/27
2	26/27	25/25	27/26	24/24	20/20	25/24
3	26/27	25/25	28/27	24/24	23/19	25/24
4	24/25	25/24	26/26	26/22	21/21	25/25
5	24/24	24/24	26/25	22/20	22/21	23/23
6	23/23	24/24	24/24	22/20	24/20	23/23
7	23/23	23/24	24/24	22/20	21/21	23/22
8	23/22	23/24	23/23	22/20	22/22	23/22
9	21/22	24/24	23/23	22/20	21/21	23/23
10	21/21	23/24	23/22	21/20	20/21	23/22
11	21/20	23/23	22/23	21/20	22/22	22/21
12	20/20	22/22	22/22	21/20	22/21	23/21
13	20/20	22/22	21/21	21/21	21/21	22/22
14	20/20	22/21	22/21	21/21	21/21	22/22
15	20/20	22/21	21/22	21/21	21/21	22/22

TABLE 50

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Groov-Pin Corporation
INSERT TYPE & SIZE - Tap Lok (NM-25028-90) 1/4-28 NYLOK
INSERT COATING -
BOLT - NAS 1304-5
INSERT MATERIAL: Hardened Stainless Steel

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	18/16	16/14	18/15	14/12	16/14	19/18
2	10/10	10/10	12/12	10/10	16/14	10/10
3	10/10	10/10	12/11	9/8	13/13	10/10
4	9/9	10/10	11/11	9/8	13/13	10/10
5	9/8	9/8	11/11	8/8	12/11	10/10
6	8/8	10/10	11/11	8/8	12/12	10/10
7	8/8	10/10	11/10	8/8	11/12	10/10
8	8/9	10/10	10/10	8/7	11/11	10/10
9	8/9	10/10	10/10	8/7	11/10	10/10
10	8/9	10/10	10/10	8/7	10/10	10/10
11	8/8	10/10	9/9	8/7	10/10	10/10
12	8/8	10/10	9/9	8/7	10/9	10/10
13	9/9	10/10	9/8	8/7	8/9	10/10
14	8/8	10/10	9/8	8/7	8/8	10/10
15	8/8	10/10	9/9	8/7	8/8	10/10

TABLE 51

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Heli-Coil Products
INSERT TYPE & SIZE - Screw Locking, CRES 3591-6CN - 3/8-24
INSERT COATING - None Used
BOLT - MS-21250
INSERT MATERIAL: CRES 18-8

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	70/60	70/70	65/65	70/70	80/70	80/65
2	65/60	65/65	65/60	60/50	60/60	65/65
3	55/50	60/55	65/55	55/50	60/60	60/65
4	60/55	60/55	60/55	60/55	55/55	55/55
5	55/55	55/55	55/50	65/60	55/50	50/50
6	55/55	50/55	55/55	65/65	55/50	50/50
7	55/50	50/50	50/50	55/60	50/50	50/50
8	50/50	50/50	50/45	50/50	50/50	50/50
9	50/45	45/50	50/45	50/50	50/50	45/45
10	45/45	45/45	45/45	45/40	50/50	45/45
11	45/45	45/45	45/40	40/40	50/45	45/40
12	45/45	45/40	45/40	40/40	50/45	40/40
13	45/45	40/40	45/50	30/30	45/45	40/40
14	45/45	40/40	45/40	30/30	45/45	40/40
15	45/45	40/40	40/40	30/30	45/45	40/45

TABLE 52

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Tridair Industries
INSERT TYPE & SIZE - Coil Lock-18-8-TLF-6C-0562 - 3/8-24
INSERT COATING - None Used
BOLT - MS-2150
INSERT MATERIAL: CRES 18-8

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS. INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	45/45	40/40	45/40	40/40	45/40	45/45
2	40/40	40/35	35/40	30/30	35/40	35/35
3	40/35	35/30	35/40	30/25	40/35	35/35
4	35/35	35/30	35/35	30/25	35/35	35/30
5	35/35	35/30	35/35	28/26	30/30	35/30
6	35/30	30/30	35/30	28/26	25/25	35/30
7	30/30	30/25	30/30	26/25	25/25	30/30
8	30/30	30/25	30/30	26/25	25/25	30/30
9	30/25	25/25	30/25	25/25	30/25	25/25
10	25/30	25/25	25/30	25/26	25/25	25/25
11	25/25	25/26	25/25	23/24	25/25	30/25
12	25/25	25/26	25/25	24/23	25/25	25/25
13	25/25	25/25	25/25	24/23	25/25	25/25
14	25/25	25/25	25/25	24/23	25/25	25/25
15	25/25	25/25	25/25	24/23	25/25	25/25

TABLE 53

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Long-Lok Corporation
INSERT TYPE & SIZE - T-Serts (T064P59) 3/8-24
INSERT COATING - Dry Film Lubricant
BOLT - MS-21250
INSERT MATERIAL: CRES 18-8

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	10/10	20/20	15/15	18/18	15/15	13/13
2	10/10	10/15	15/15	18/17	15/13	13/11
3	10/10	10/15	15/14	18/17	15/13	13/13
4	10/10	15/15	15/14	17/16	15/13	12/12
5	10/10	15/15	15/15	17/17	10/12	12/12
6	10/10	10/13	15/14	17/15	10/12	13/12
7	10/10	10/12	12/13	16/14	10/11	12/11
8	10/10	10/10	12/13	16/14	10/11	11/12
9	10/10	10/10	12/12	15/12	10/10	11/10
10	10/10	10/10	12/12	15/12	10/10	12/11
11	10/9	10/9	10/11	13/10	10/10	11/10
12	9/9	10/9	10/12	13/10	10/10	11/10
13	9/8	10/9	10/10	10/11	10/10	10/10
14	9/9	10/9	10/10	11/10	10/9	10/10
15	9/9	10/9	10/10			

TABLE 54

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Torkon Fastener Corporation
INSERT TYPE & SIZE - Threadline (Tl 1011-223) 3/8-24
INSERT COATING - Dry Film Lubricant
BOLT - MS-21250
INSERT MATERIAL: CRES 18-8

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFC.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	55/55	40/40	50/50	50/50	45/45	55/50
2	50/45	30/30	50/45	45/45	40/40	50/50
3	45/40	30/35	45/45	45/50	40/35	50/45
4	40/35	30/30	45/40	45/40	40/30	45/45
5	30/30	30/30	40/40	40/40	40/30	40/40
6	30/40	30/25	40/45	40/35	30/30	40/35
7	35/35	30/25	35/35	35/35	30/30	35/35
8	35/35	30/25	35/40	35/35	30/35	35/40
9	30/35	25/25	35/30	35/30	30/30	35/35
10	30/35	25/25	30/30	30/35	30/25	30/25
11	30/35	25/25	30/30	30/35	30/25	30/30
12	30/35	25/25	25/25	30/30	25/30	30/30
13	35/35	25/25	25/25	30/30	25/25	20/25
14	30/30	25/20	25/25	30/30	25/20	30/25
15	30/30	25/20	25/25	30/30	25/20	30/25

TABLE 55

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Kaynar
INSERT TYPE & SIZE - Thin Wall, Self-Locking (K8000-6) 3/8-24
INSERT COATING - Cadmium Plated & Kaylube Moly-disulfide Dry Film Lube.
BOLT - MS-21250
INSERT MATERIAL: Alloy Steel, Heat-Treated

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	65/65	70/65	60/60	65/65	60/60	65/65
2	50/50	55/55	60/55	60/60	55/50	60/60
3	50/50	50/50	55/50	55/60	55/55	60/65
4	47/50	50/50	40/42	55/55	55/50	55/55
5	45/50	50/50	45/45	55/50	50/45	55/50
6	45/50	50/50	45/45	50/50	50/45	50/50
7	40/45	50/50	45/45	45/45	40/40	45/50
8	40/45	50/50	45/45	45/40	40/40	45/45
9	45/50	50/50	45/45	45/50	40/45	45/45
10	45/50	50/50	42/45	45/45	40/40	45/45
11	45/50	45/50	45/45	40/40	40/40	45/45
12	40/45	50/50	45/45	40/45	40/40	45/40
13	40/45	45/45	45/45	40/40	40/40	45/40
14	40/45	45/45	45/45	40/40	40/40	45/40
15	40/45	45/45	45/40	40/40	40/40	45/40

TABLE 56

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Rosan
INSERT TYPE & SIZE - Slim Sert (SR 374L) 3/8-24
INSERT COATING - Dry Film Lubricant
BOLT - MS-21250
INSERT MATERIAL: 17-4 PH Stainless Steel

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	80/75	85/80	75/75	85/80	70/70	75/75
2	70/70	75/75	75/75	75/70	70/70	70/70
3	70/70	78/75	70/70	75/75	70/75	70/70
4	70/70	80/80	70/70	80/80	70/70	75/70
5	70/70	80/80	70/70	75/75	70/65	70/65
6	70/70	80/80	70/70	75/70	70/65	70/70
7	70/70	75/75	70/70	70/70	65/65	70/70
8	70/70	70/75	70/75	70/70	65/65	70/65
9	70/70	70/70	70/65	70/75	65/65	70/65
10	70/70	70/70	65/65	70/70	65/65	70/65
11	70/70	70/70	65/65	70/70	65/60	70/65
12	70/70	70/70	65/65	70/65	65/60	70/65
13	70/70	70/70	65/65	70/65	65/60	70/65
14	70/65	70/70	65/65	70/65	65/60	70/65
15	70/65	70/70	65/65	70/65	65/60	70/65

TABLE 57

ROOM TEMPERATURE LOCKING UNLOCKING TORQUE TESTS

INSERT MANUFACTURER - Groov-Pin Corporation
INSERT TYPE & SIZE - Tap Lok (NM 37524-90) 3/8-24 NYLOK
INSERT COATING -
BOLT - MS-21250
INSERT MATERIAL: Hardened Stainless Steel

CYCLE	BOLT LOCKING/UNLOCKING TORQUE - IN-LBS.					
	INSERTS INSTALLED BY AFML			INSERTS INSTALLED BY MFG.		
	SAMPLE NUMBER					
	1	2	3	1	2	3
1	50/45	45/35	45/45	46/40	50/50	45/45
2	30/30	30/30	40/40	40/40	40/35	40/40
3	25/25	30/30	40/40	40/35	30/30	35/40
4	20/20	25/25	35/40	35/35	30/25	35/35
5	20/20	25/25	35/35	35/30	25/25	25/25
6	20/20	20/25	25/25	20/20	25/20	20/20
7	15/15	20/20	25/20	15/15	14/15	14/14
8	15/15	20/15	20/20	15/15	14/15	14/14
9	15/15	15/14	20/20	15/15	15/15	14/14
10	15/15	15/15	15/15	15/15	15/15	14/14
11	15/15	15/14	15/15	15/15	14/14	13/14
12	15/15	14/14	15/15	15/15	14/14	13/14
13	15/15	14/14	15/15	15/15	14/14	13/13
14	15/15	14/14	15/15	15/14	14/14	13/13
15	15/15	14/14	15/15	15/15	14/14	13/13

TABLE 58

AVERAGES OF THE FIRST CYCLE, SEVENTH CYCLE AND FIFTEENTH CYCLE
OF THE LOCKING AND BREAKAWAY TORQUE TEST FOR EACH SIZE INSERT

MANUFACTURER	NOMINAL BOLT SIZE	FIRST - CYCLE LOCKING/BREAKAWAY TORQUE - IN-LBS		SEVENTH - CYCLE LOCKING/BREAKAWAY TORQUE - IN-LBS.		FIFTEENTH - CYCLE LOCKING/BREAKAWAY TORQUE - IN-LBS.	
Heli-Coil	10-32	8.5	7.4	5.7	5.6	5.2	5.0
	1/4-28	22.0	19.5	15.2	14.8	14.0	13.0
	3/8-24	72.5	66.6	51.7	51.7	40.0	40.8
Tridair	10-32	3.9	3.6	2.5	2.6	2.3	2.3
	1/4-28	22.1	21.3	20.0	19.7	19.5	19.1
	3/8-24	43.3	41.6	28.5	27.5	24.8	24.6
Rosan	10-32	12.2	10.6	7.7	6.7	6.9	6.6
	1/4-28	29.2	27.3	22.7	22.3	21.2	21.2
	3/8-24	78.3	75.8	70.0	70.0	68.3	65.0
Kaynar	10-32	7.6	7.3	6.0	5.8	5.8	5.2
	1/4-28	26.2	25.2	20.8	20.7	19.6	19.5
	3/8-24	64.2	63.3	44.2	45.8	42.5	41.6
Long-Lok	10-32	4.2	4.0	3.2	3.2	2.8	2.7
	1/4-28	4.6	4.5	3.7	3.5	3.5	3.3
	3/8-24	15.2	15.2	11.7	11.8	10.0	9.5
Torkon	10-32	6.9	6.6	4.9	5.0	3.9	4.0
	1/4-28	25.8	24.1	15.7	15.0	13.8	13.5
	3/8-24	49.1	48.3	33.3	32.5	27.5	26.6
Gr[illegible]-Pin	10-32	10.1	8.5	5.8	5.9	5.3	5.3
	1/4-28	16.8	14.8	9.7	9.7	8.8	8.6
	3/8-24	46.8	43.3	17 2	16.5	14.3	14.3

NOTE: The averages include both AFML and Manufacturer installed inserts

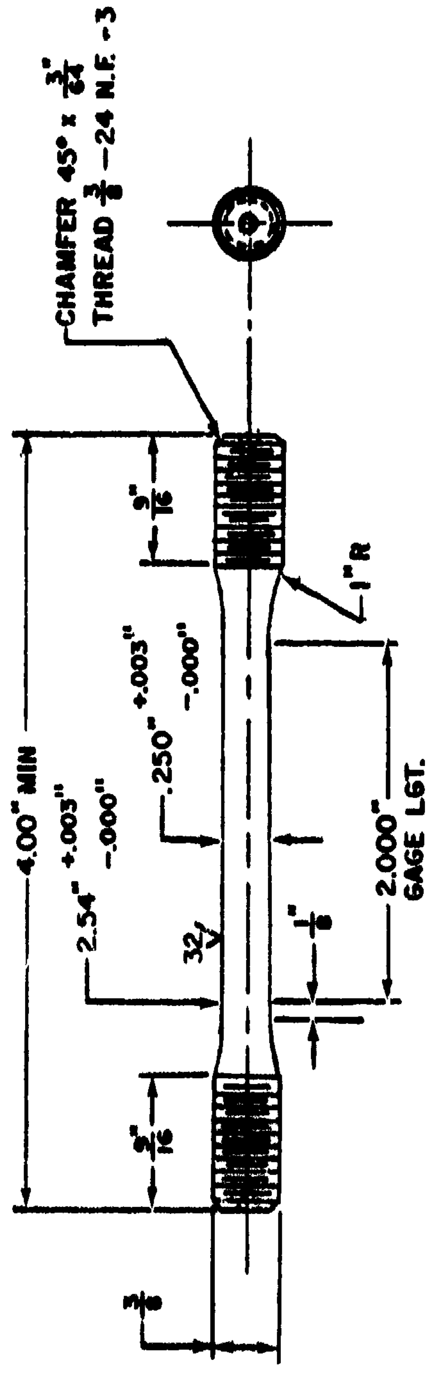


Figure 5. Tensile Test Specimen

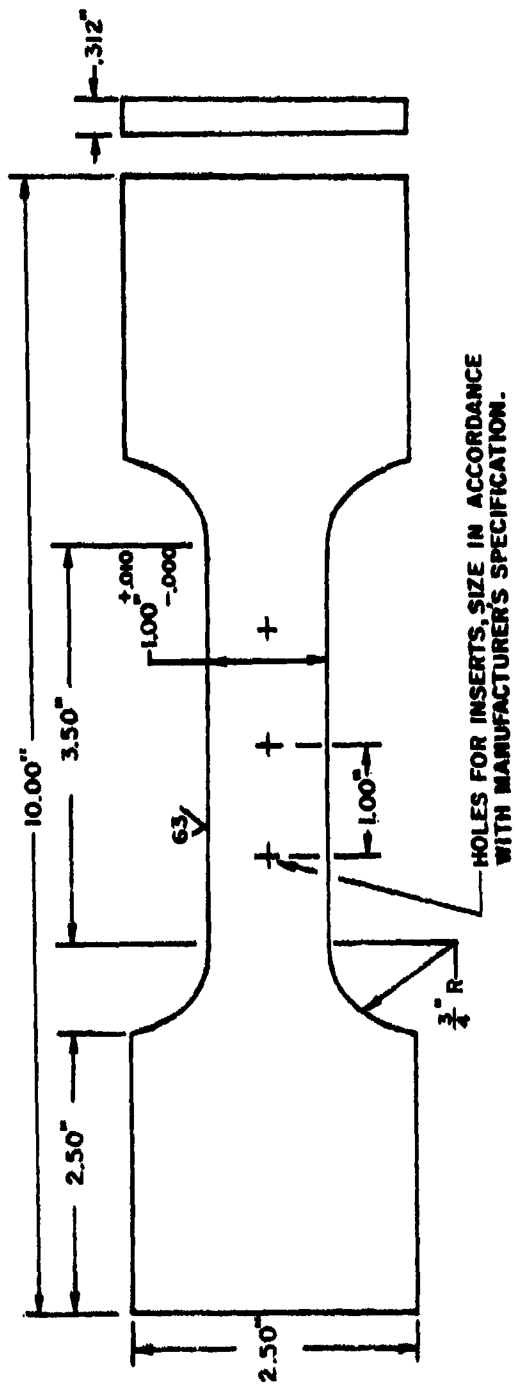


Figure 6. Fatigue Specimen for 10-32 Insert

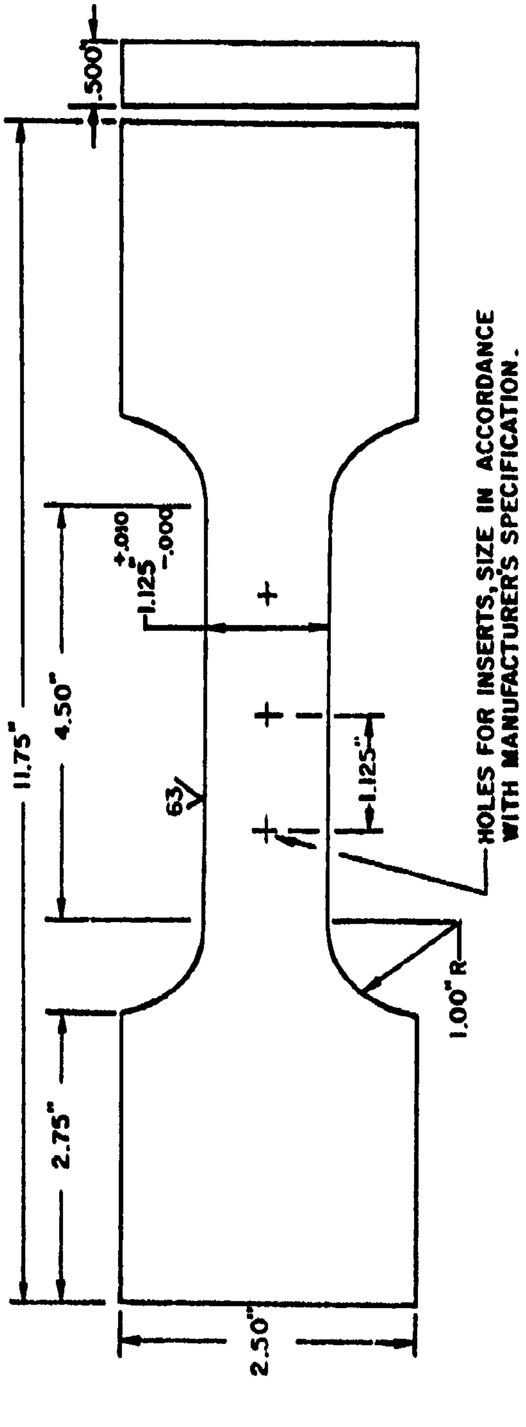


Figure 7. Fatigue Specimen for 1/4-28 Insert

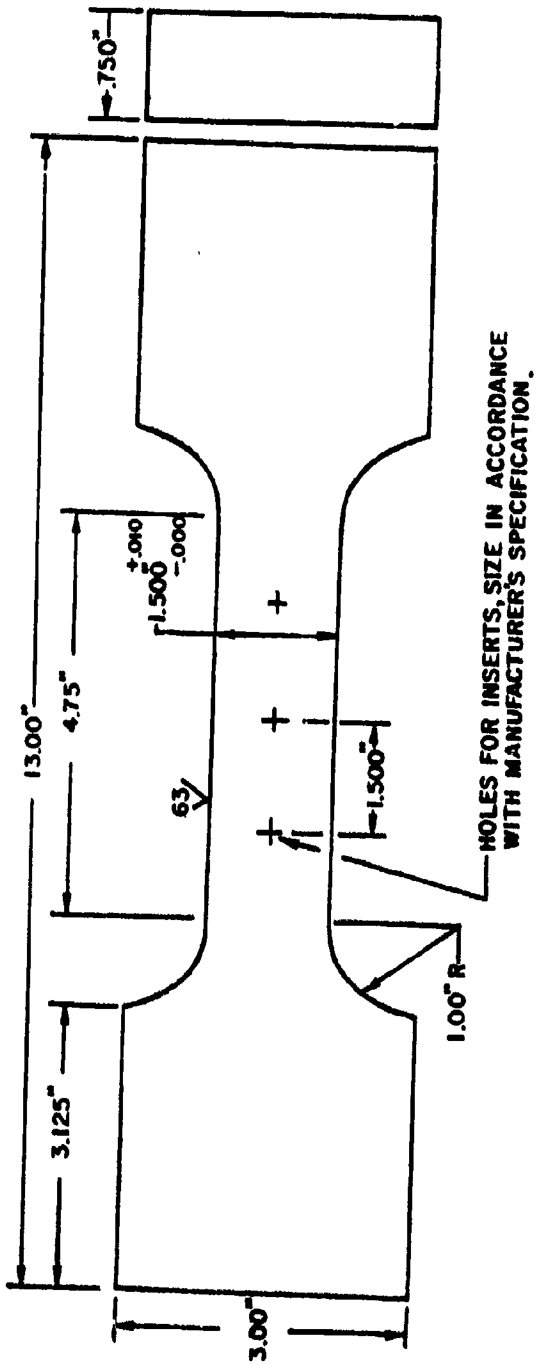


Figure 8. Fatigue Specimen for 3/8-24 Insert

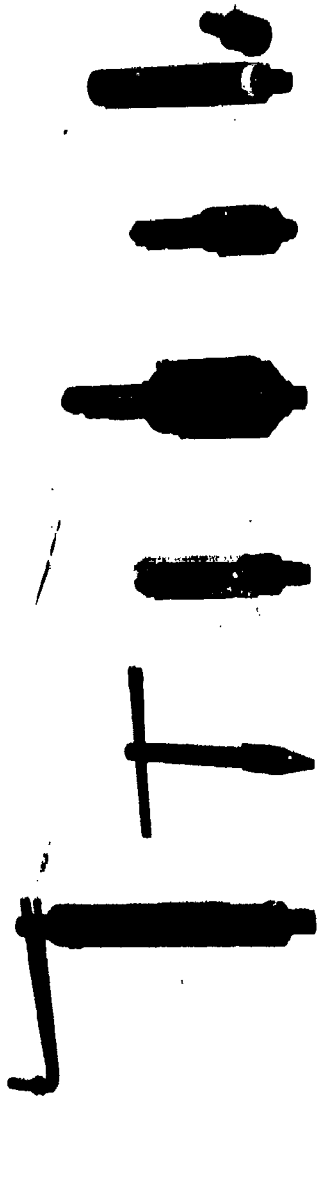


Figure 9. Installation Tools for Threaded Inserts. Also Shown is the Heli-Coil Insert Removal Tool.

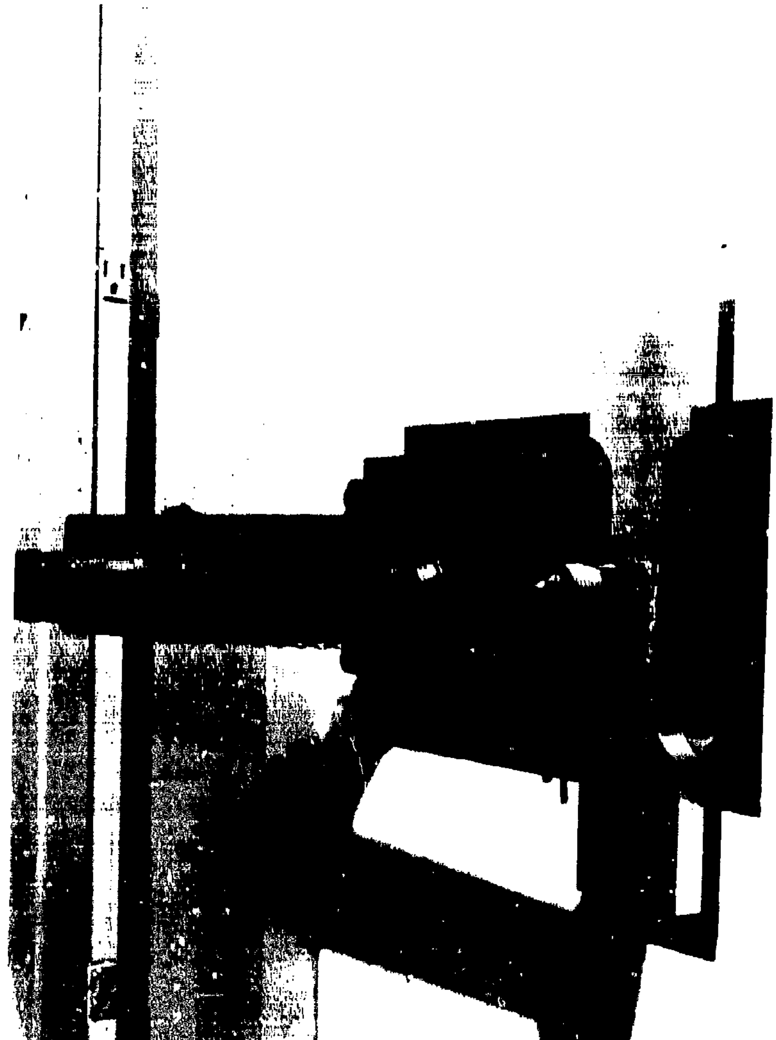


Figure 10. Alignment Fixture for Starting Groov-Pin Self-Tapping Insert

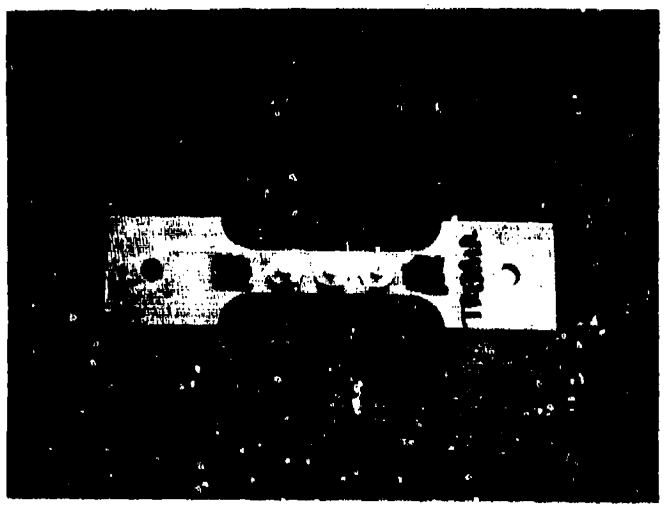


Figure 11. Fatigue Specimen with Inserts and Bolts Installed

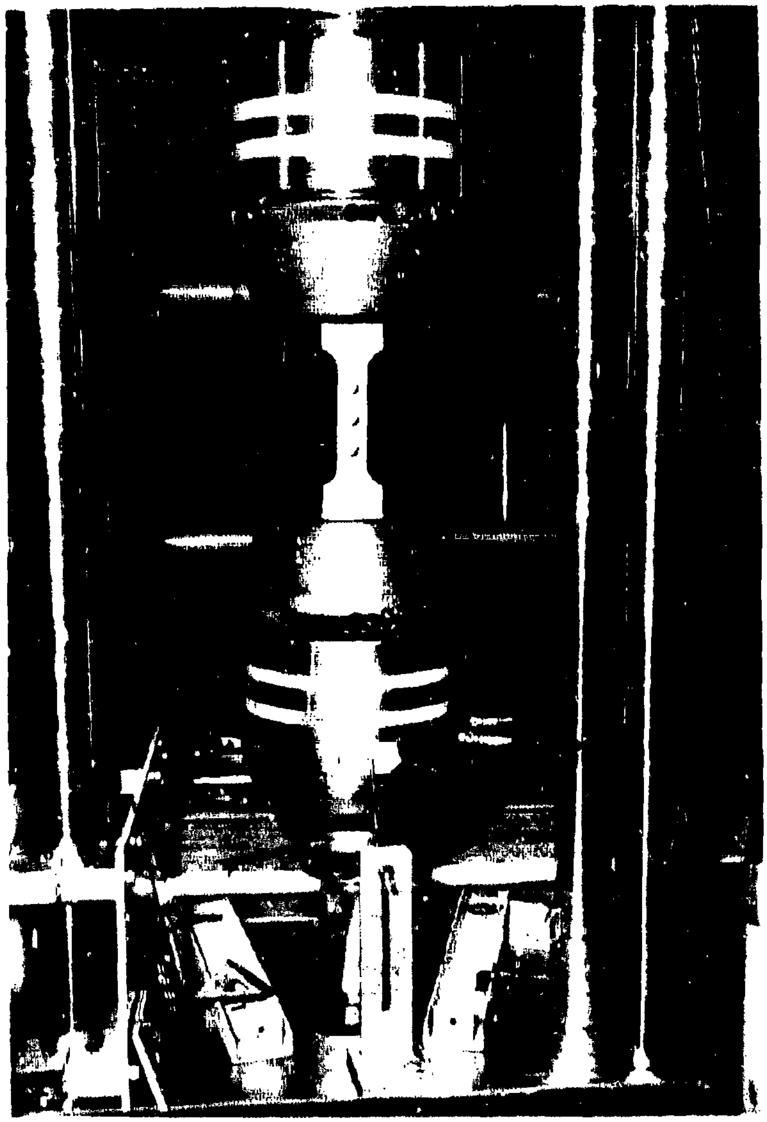


Figure 12. Fatigue Specimen in MTS Universal Test Machine

Figure 13. Fractured Fatigue Specimen with Inserts

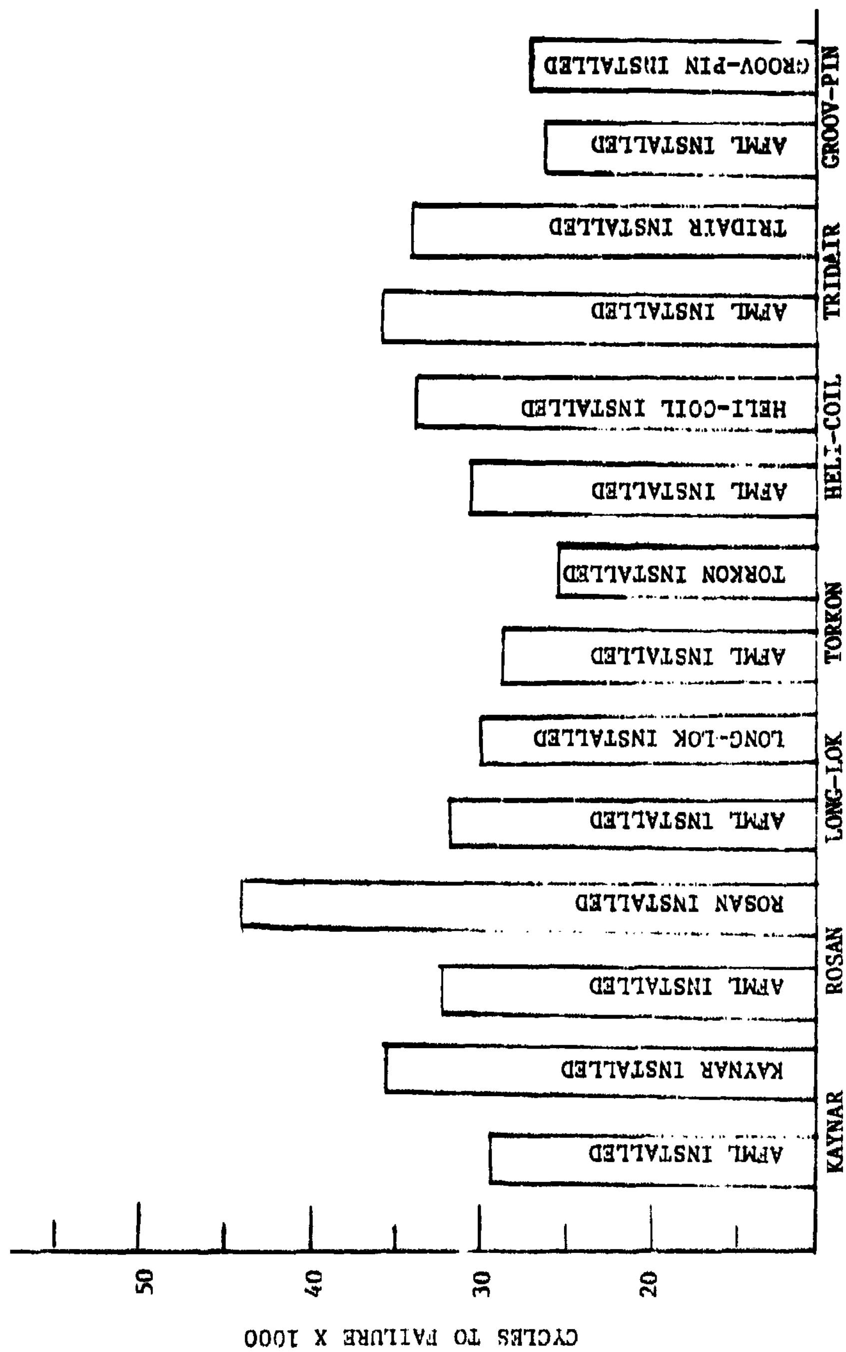


Figure 14. Bar Graph Showing the Fatigue Life of the 7075-T73 Alloy with 1/4-28 Inserts Only

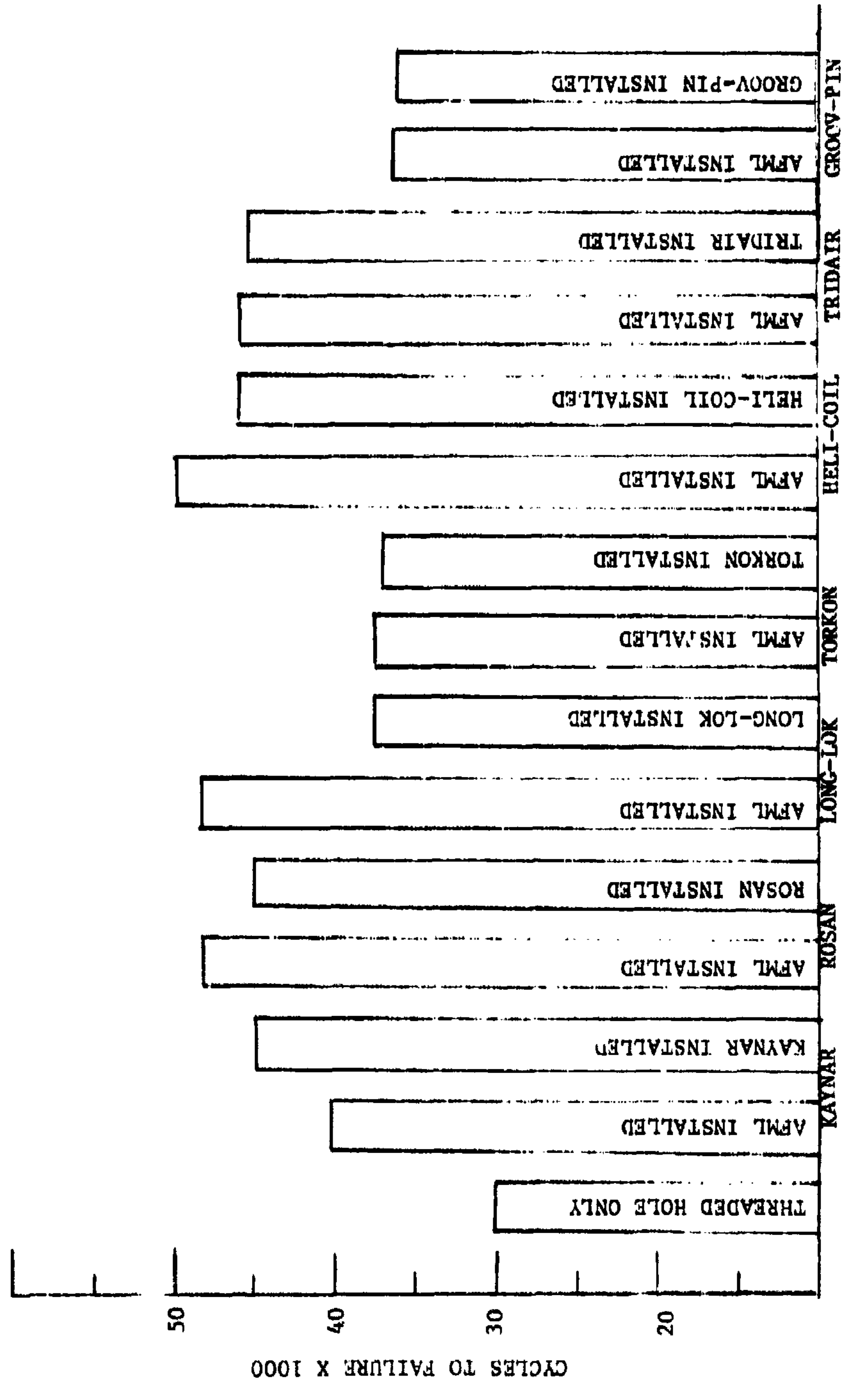


Figure 15. Bar Graph Showing Fatigue Life of the 7075-T73 Alloy with 1/4-28 Inserts and Bolts

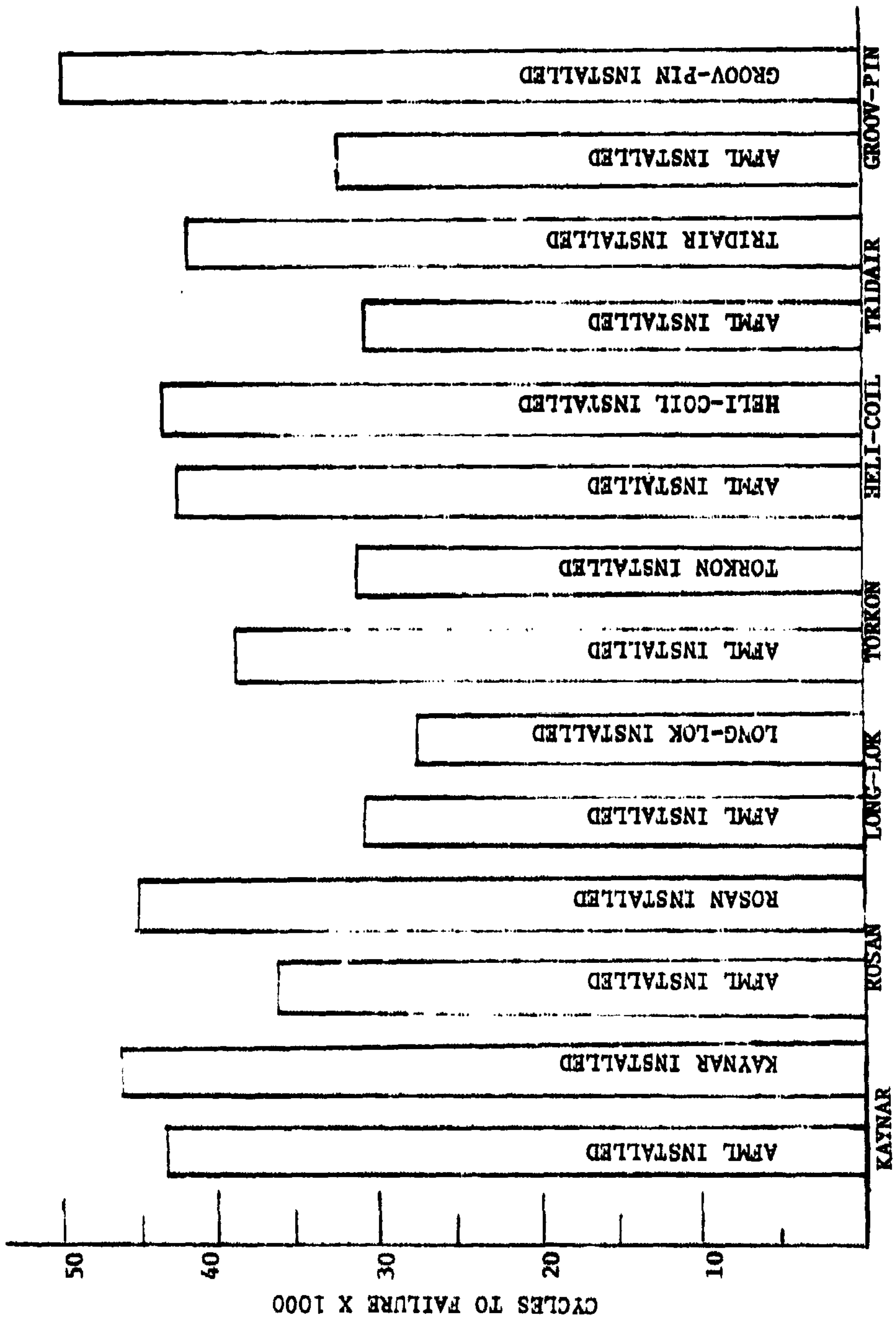


Figure 16. Bar Graph Showing the Fatigue Life of the 7075-T73 Alloy with 10-32 Size Inserts & Bolts Installed

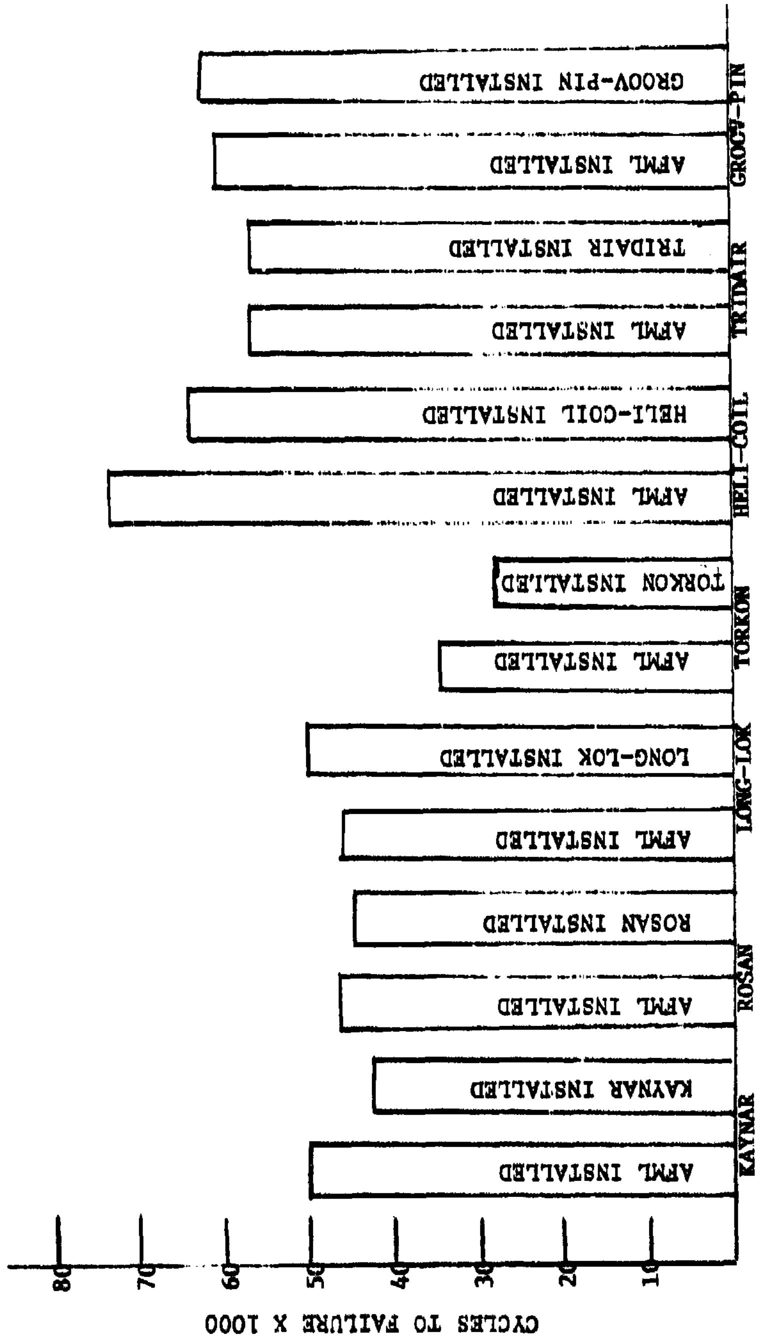


Figure 17. Bar Graph Showing the Fatigue Life of 7075-T73 Alloy with 3/8-24 Size Inserts and Bolts

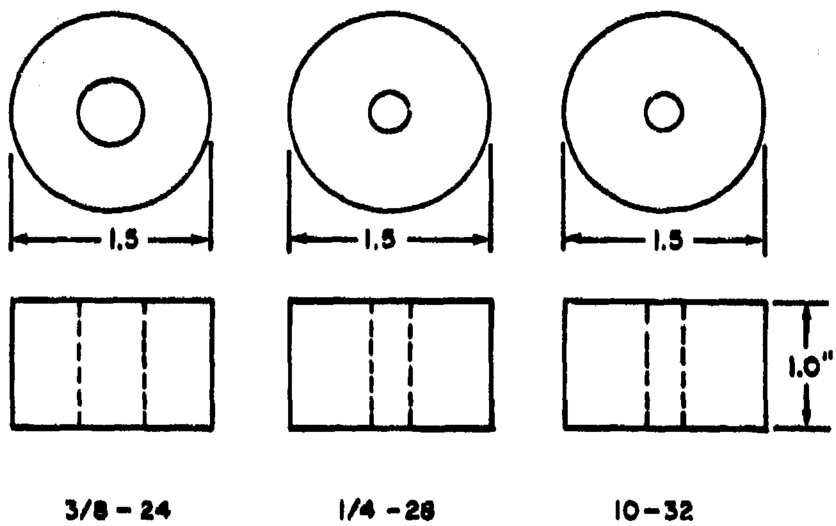


Figure 18. Insert Pull Out Specimens and Corrosion Specimen

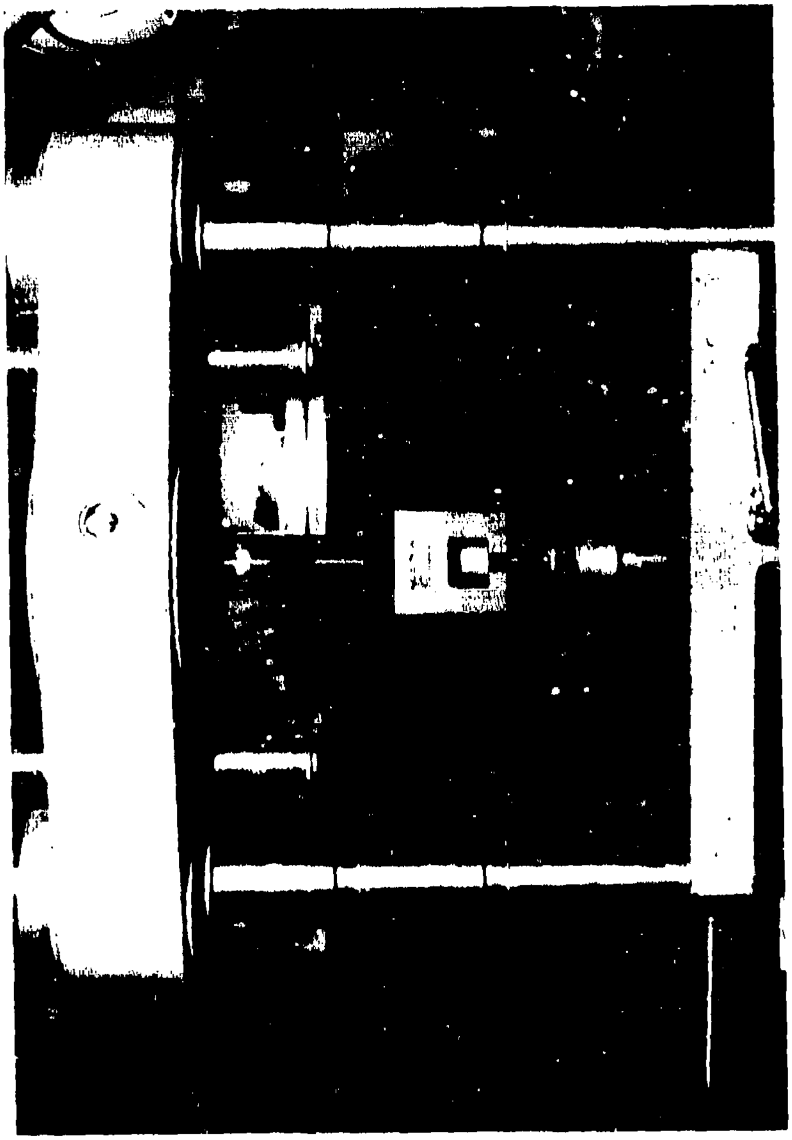


Figure 19. Test Set-up for the Tensile Pull Out of Threaded Inserts

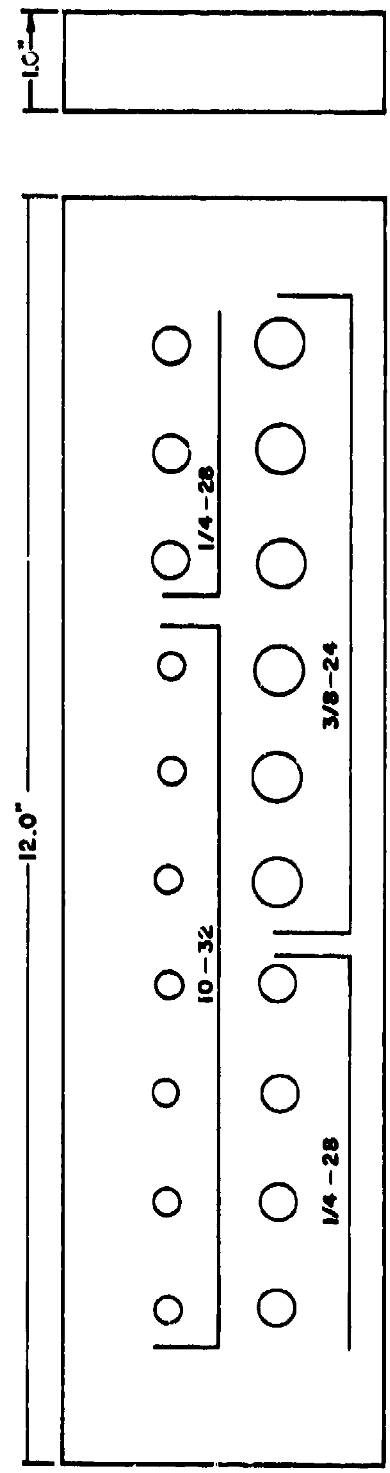


Figure 20. Locking & Unlocking Torque Specimen Lay Out

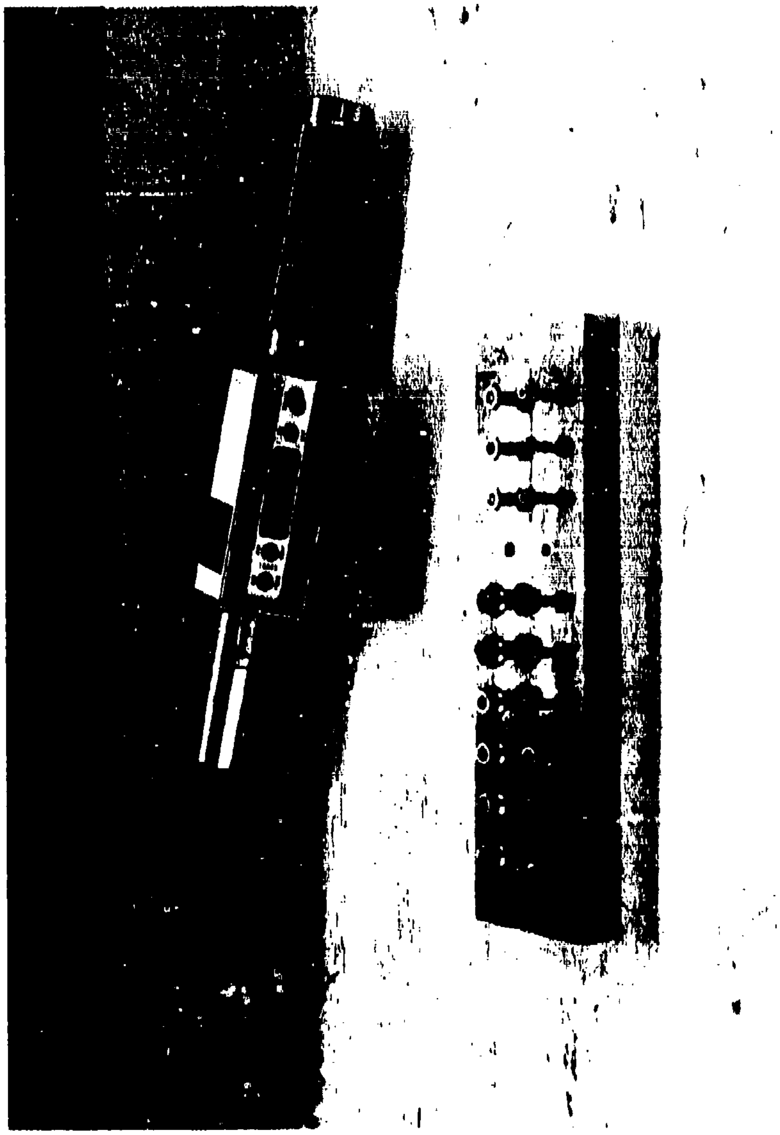
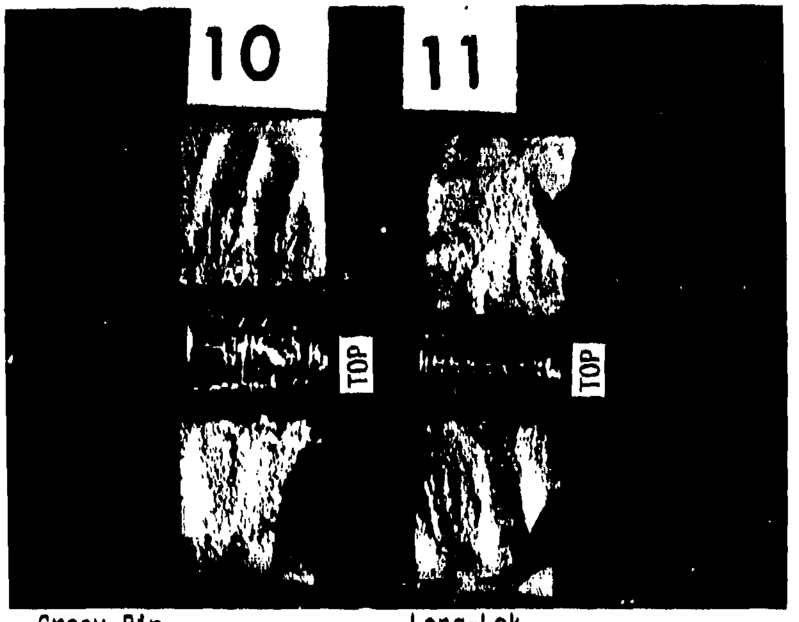
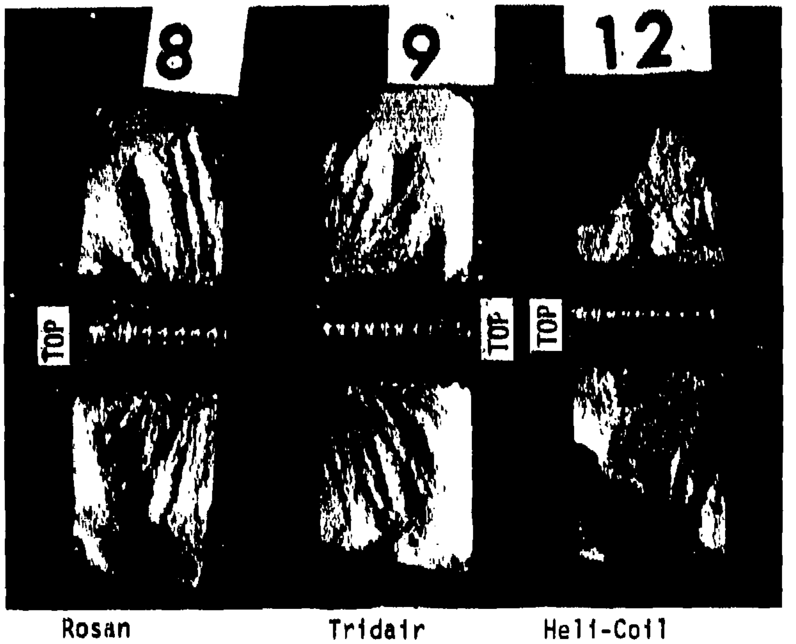


Figure 21. Typical Torque Wrench and Specimen for Locking and Breakaway Torque Tests



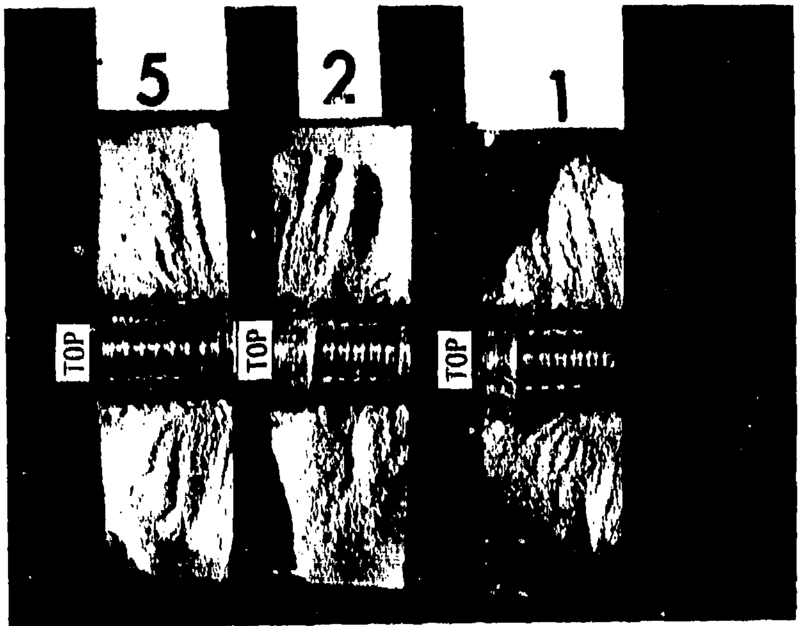
Groov-Pin Long-Lok

Figure 22. Close-up of Fatigue Failure of Specimens with Groov-Pin and Long-Lok 10-32 Size Inserts. Inserts Installed by Manufacture. Torqued Bolts in Insert During Tests.



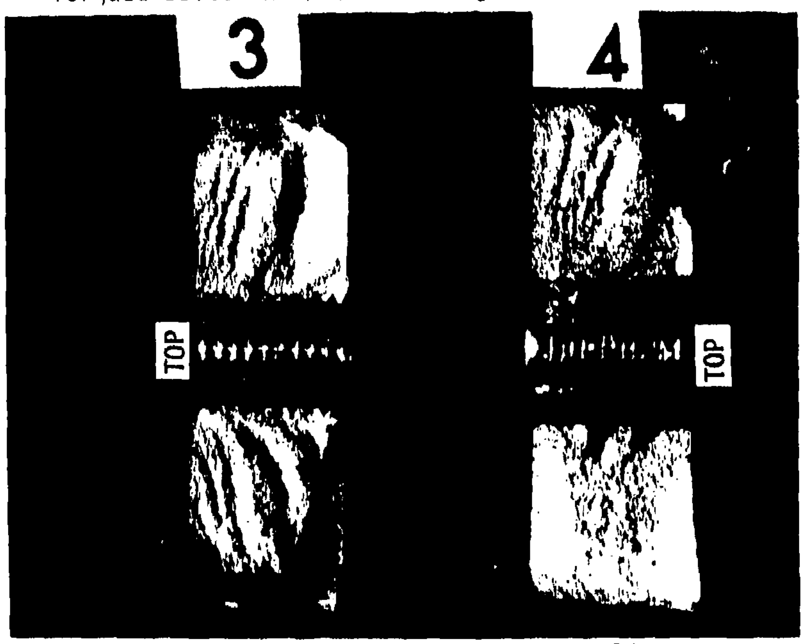
Rosan Tridair Heli-Coil

Figure 23. Close-up of Fatigue Failures of Specimens with Rosan, Tridair, and Heli-Coil 10-32 Size Insert. Inserts Installed by Manufacture. Torqued Bolts in Inserts During Tests.



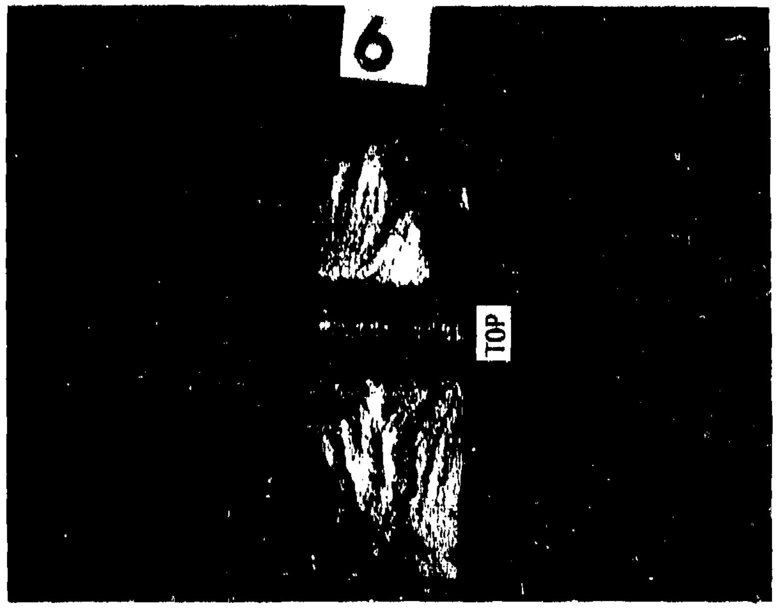
Long-Lok Rosan Kaynar

Figure 24. Close-up of Fatigue Failures of Specimens with Long-Lok, Rosan, and Kaynar 10-32 Size Inserts. Inserts Installed by AFML. Torqued Bolts in Inserts During Tests.



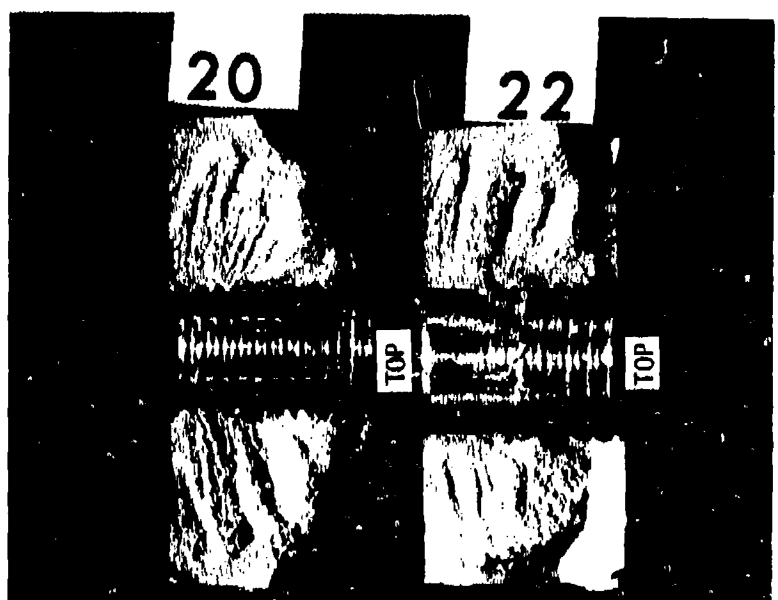
Tridair Groov-Pin

Figure 25. Close-up of Fatigue Failures of Specimens with Tridair and Groov-Pin 10-32 Size Inserts. Inserts Installed by AFML. Torqued Bolts in Inserts During Tests.



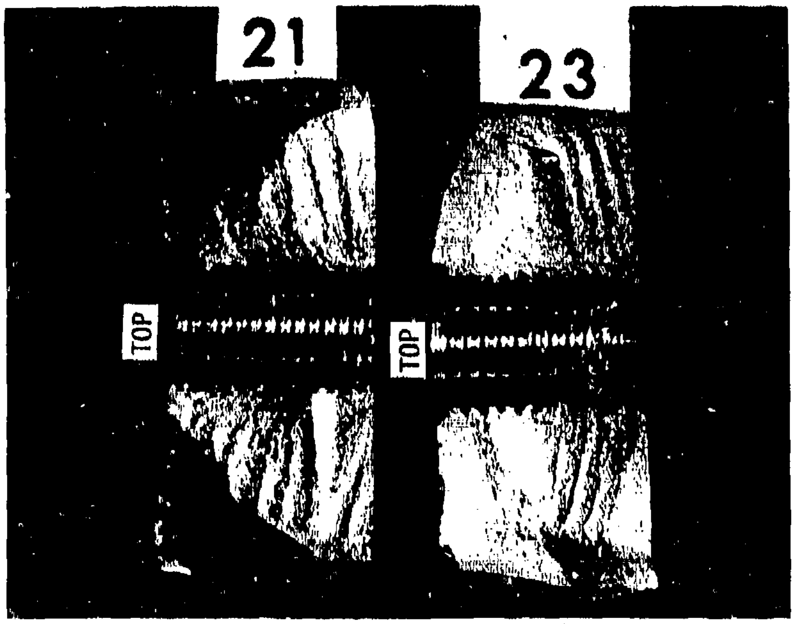
Heli-Coil

Figure 26. Close-up of Fatigue Failure of Specimen with Heli-Coil Insert. Insert Installed by AFML. Torqued Bolts in Insert During Test.



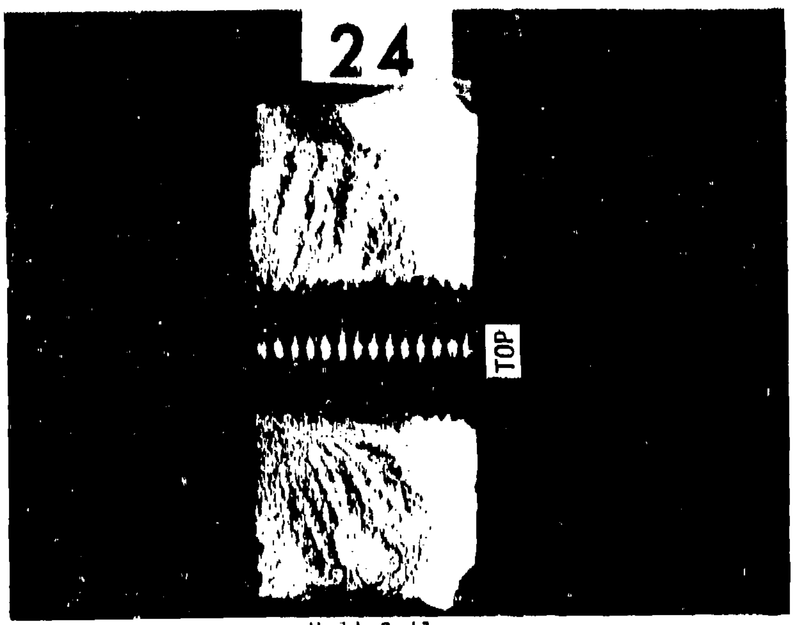
Rosan Groov-Pin

Figure 27. Close-up of Fatigue Failure of Specimens with Rosan and Groov-Pin 1/4-28 Size Insert. Inserts Installed by Manufacture. Torqued Bolts in Inserts During Tests.



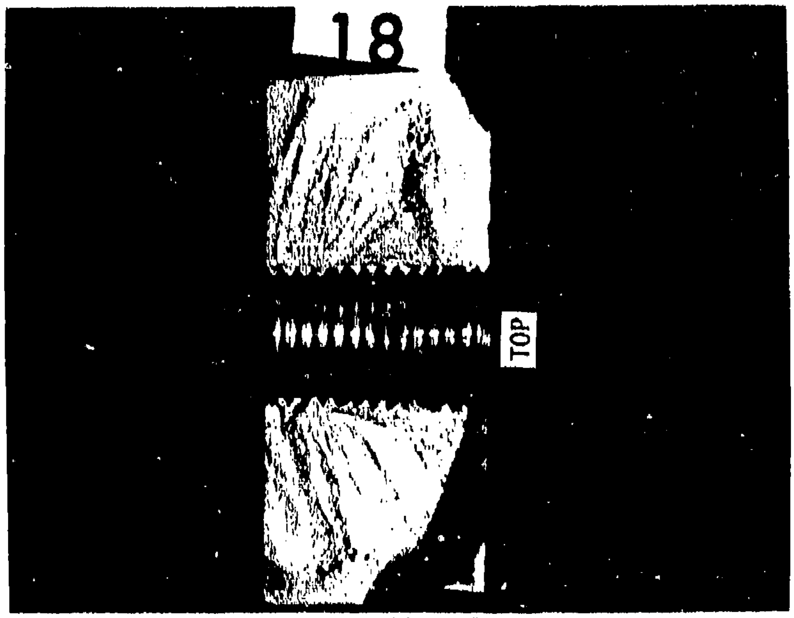
Tridair Long-Lok

Figure 28. Close-up of Fatigue Failures of Specimens with Tridair and Long-Lok 1/4-28 Size Inserts. Inserts Installed by Manufacture. Torqued Bolts in Inserts During Tests.



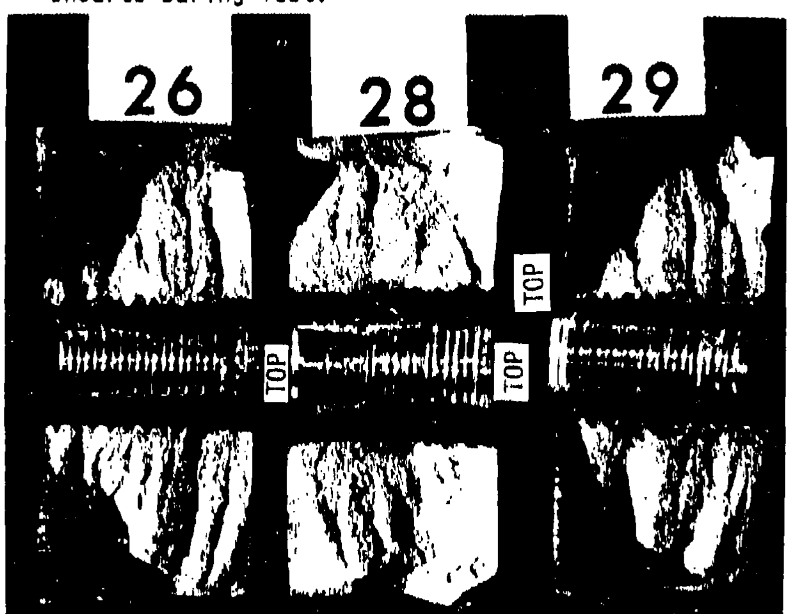
Heli-Coil

Figure 29. Close-up of Fatigue Failure of Specimens with Heli-Coil 1/4-28 Size Inserts. Torqued Bolts in Inserts During Tests.



Heli-Coil

Figure 30. Close-up of Fatigue Failure of Specimens with Heli-Coil 1/4-28 Size Insert. Inserts Installed by AFML. Torqued Bolt in Inserts During Test.



Rosan Groov-Pin Long-Lok

Figure 31. Close-up of Fatigue Failure of Specimens with Rosan, Groov-Pin, and Long-Lok 1/4-28 Size Insert. Inserts Installed by AFML. No Bolt in Inserts.

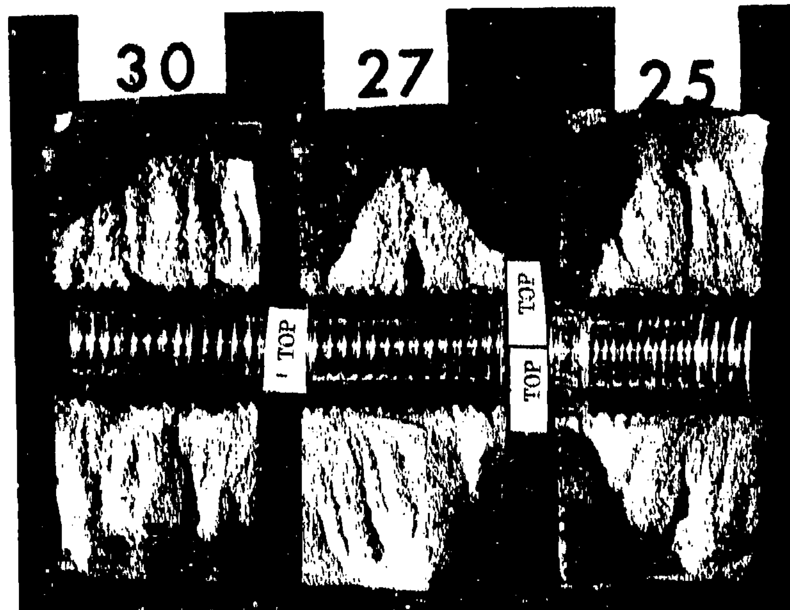


Figure 32. Close-up of Fatigue Failure of Specimens with Heli-Coil, Tridair, and Kaynar 1/4-28 Size Inserts. Inserts Installed by AFML. No Bolt in Inserts.

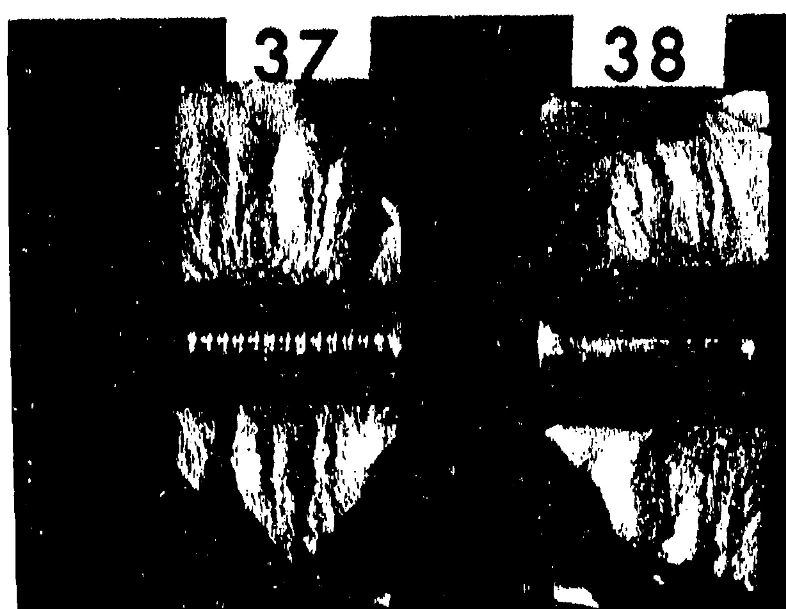


Figure 33. Close-up of Fatigue Failures of Specimens with No Inserts. 1/4 Inch Diameter Holes.

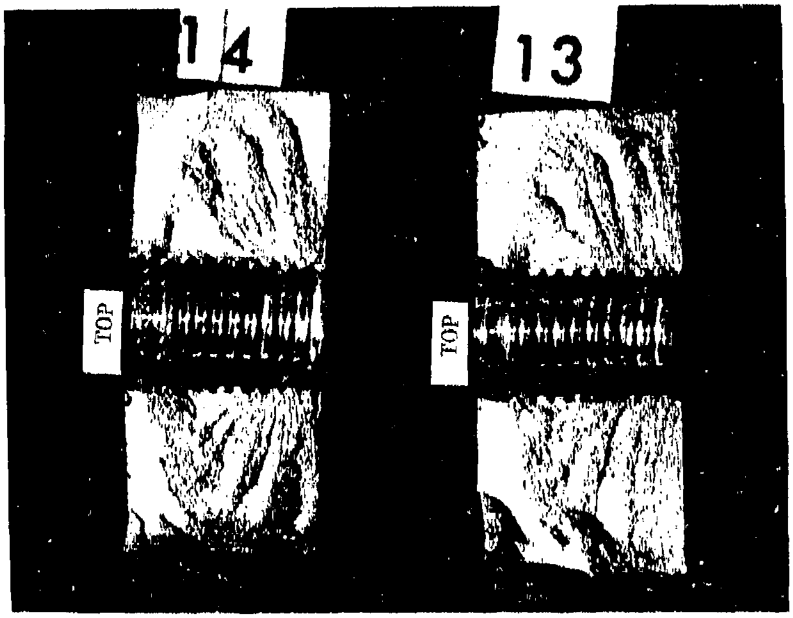


Figure 34. Close-up of Fatigue Failure of Specimen with Rosan and Kaynar 1/4-28 Size Inserts. Inserts Installed by AFML. Torqued Bolts in Inserts During Tests.

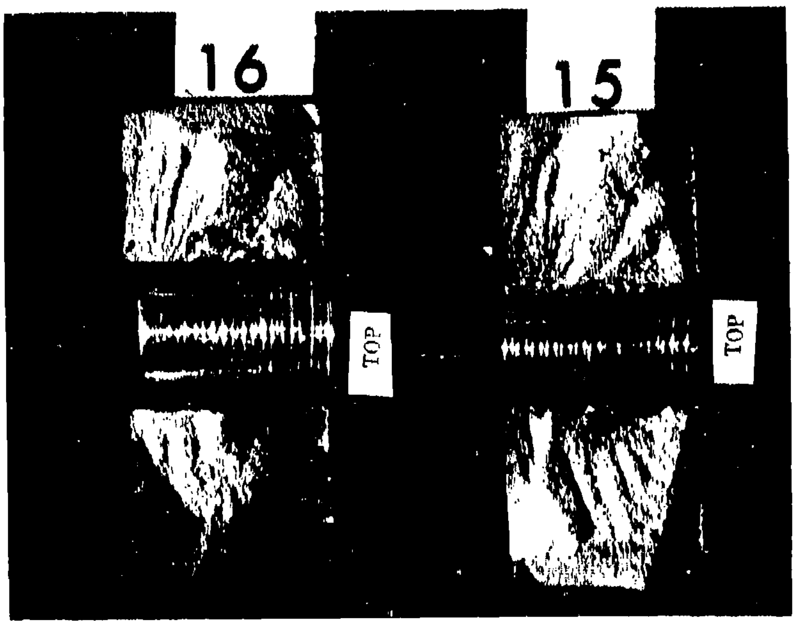
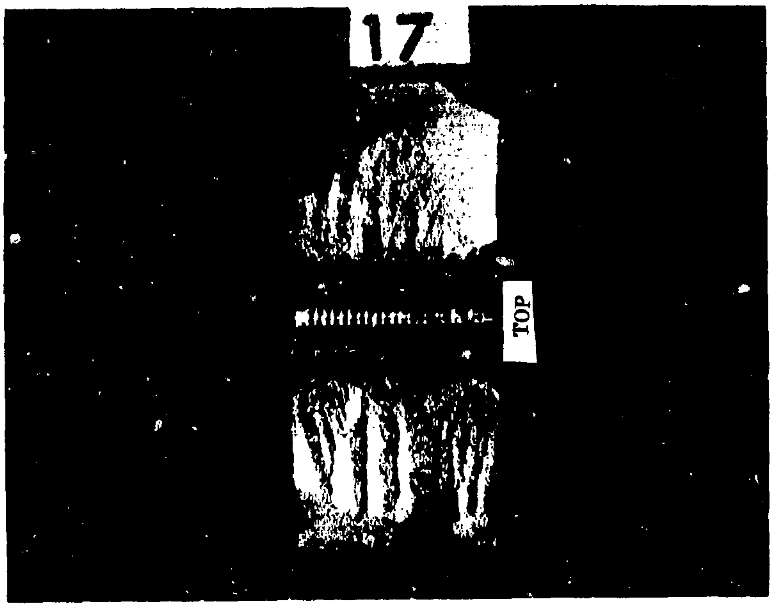


Figure 35. Close-up of Fatigue Failures of Specimens with Groov-Pin and Tridair 1/4-28 Size Inserts. Inserts Installed by AFML. Torqued Bolts in Inserts During Tests.



1/4 - 28

Figure 36. Close-up of Fatigue Failure of Specimens with Long-Lok Insert. Inserts Installed by AFML. Torqued Bolts in Inserts During Test.

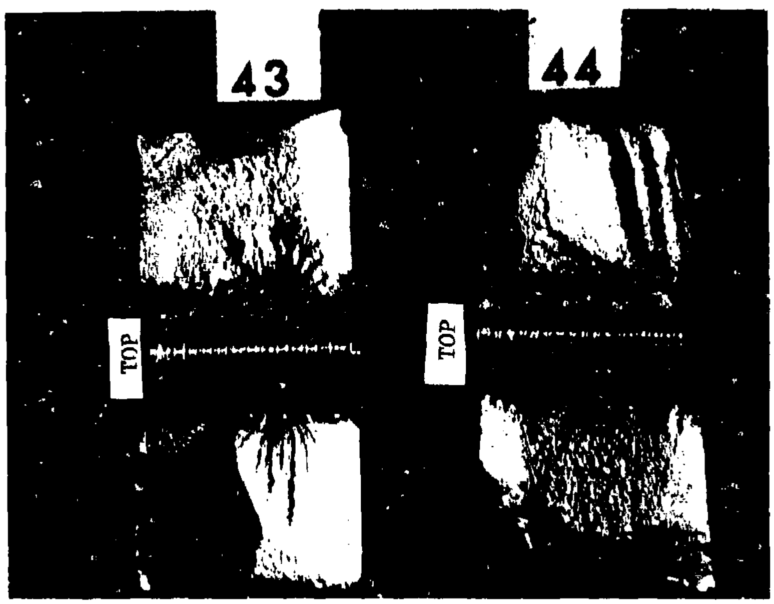


Figure 37. Close-up of Fatigue Failures of Specimens with Long-Lok and Heli-Coil 3/8-24 Size Inserts. Inserts Installed by AFML. Torqued Bolts in Inserts During Tests.

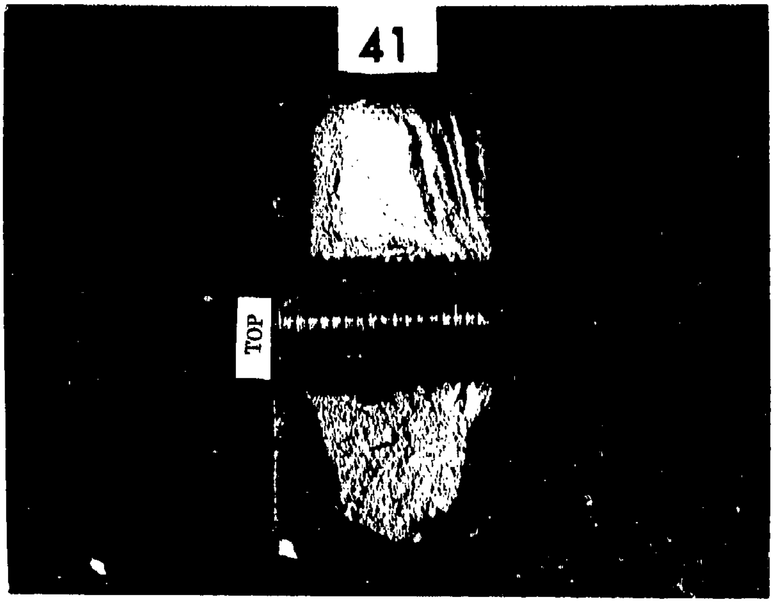


Figure 38. Close-up of Fatigue Fracture of Specimens with Tridair 3/8-24 Size Insert. Insert Installed by AFML. Torqued Bolt in Inserts During Test.

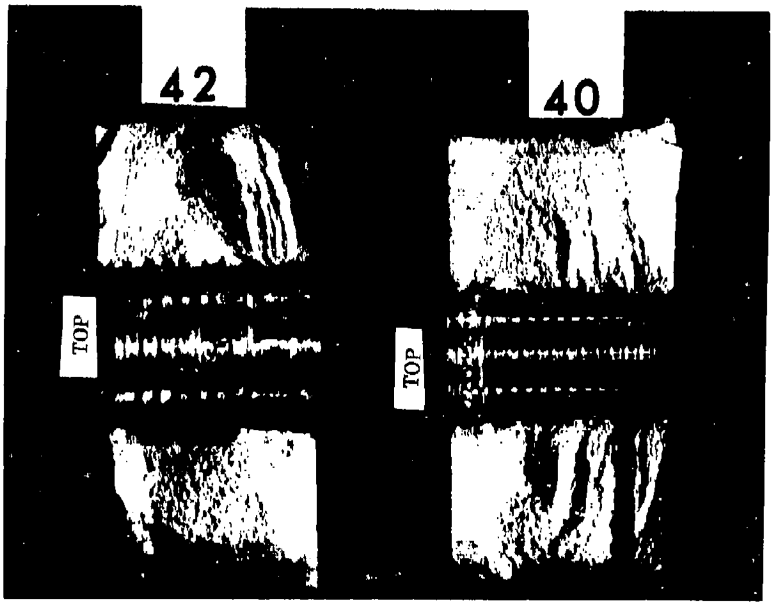


Figure 39. Close-up of Fatigue Failures of Specimens with Groov-Pin and Rosan 3/8-24 Size Inserts. Inserts Installed by AFML. Torqued Bolts in Inserts During Tests.

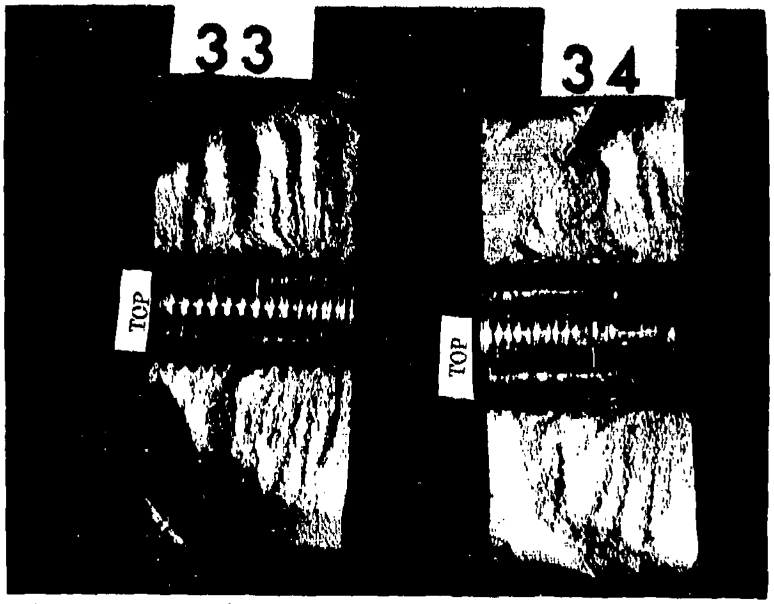


Figure 40. Close-up of Fatigue Failure of Specimens with Tridair and Groov-Pin 1/4-28 Size Insert. Inserts Installed by Manufacture.

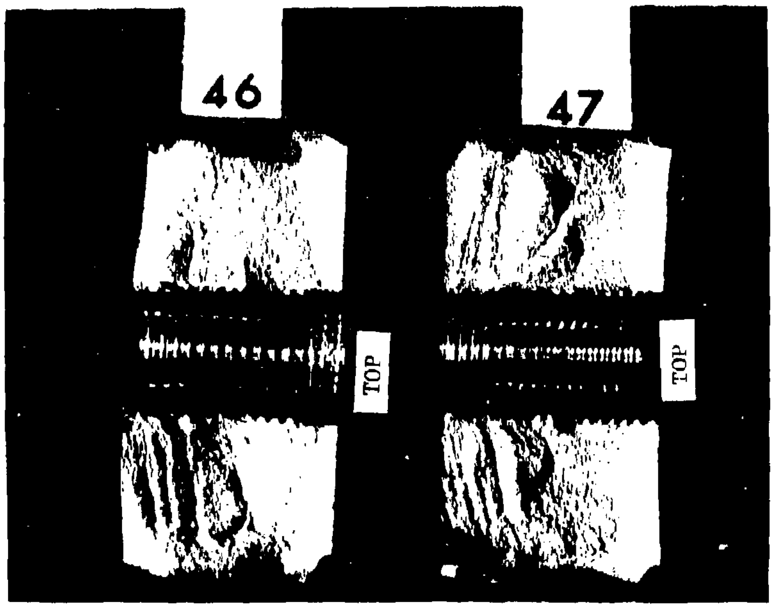


Figure 41. Close-up of Fatigue Failures of Specimen with Rosan and Tridair 3/8-24 Size Inserts. Inserts Installed by Manufacture. Torqued Bolts in Inserts During Tests.

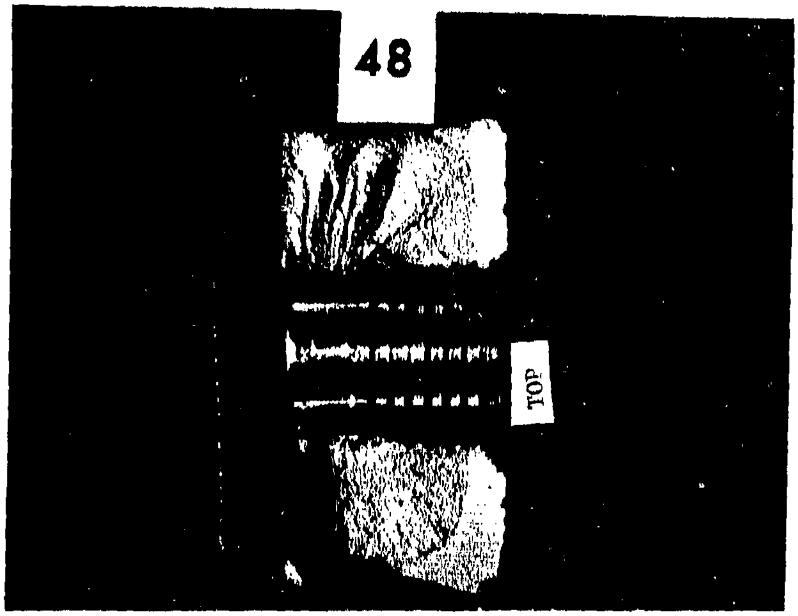


Figure 42. Close-up of Fatigue Failure of Specimens with Groov-Pin Size Inserts. Inserts Installed by Manufacture. Torqued Bolts in Inserts During Test.

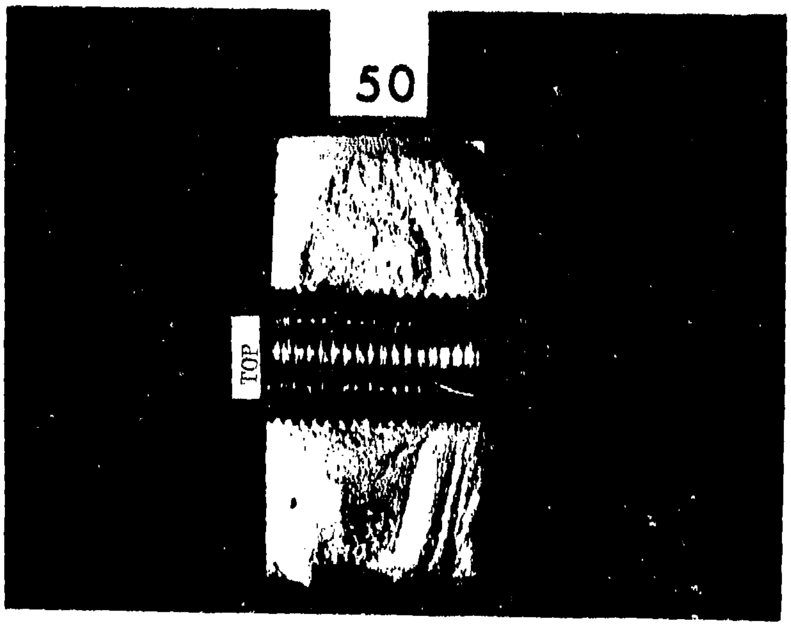


Figure 43. Close-up of Fatigue Failure of Specimens with Heli-Coil 3/8-24 Size Inserts. Inserts Installed by Manufacture. Torqued Bolts in Inserts During Test

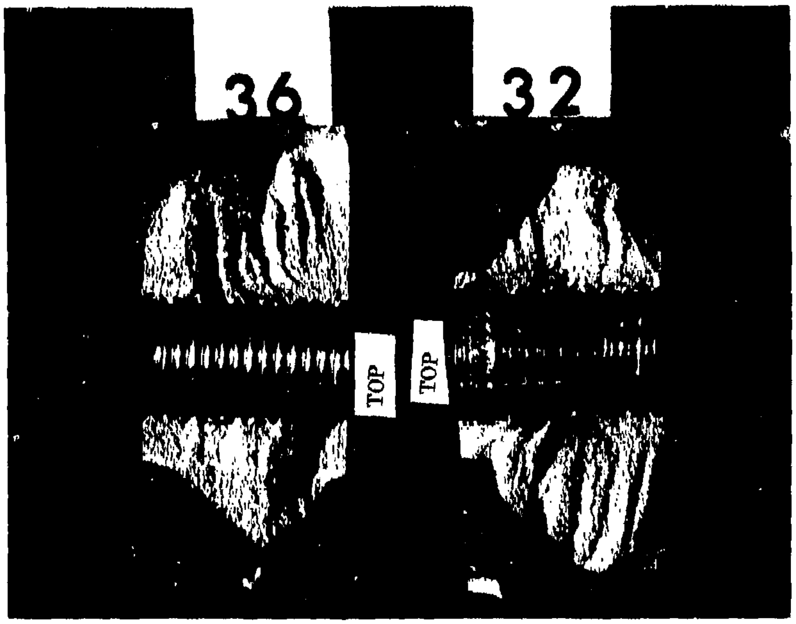


Figure 44. Close-up of Fatigue Failure of Specimens with Heli-Coil and Rosan 1/4-28 Size Inserts. Inserts Installed by Manufacture. No Bolt in Inserts.

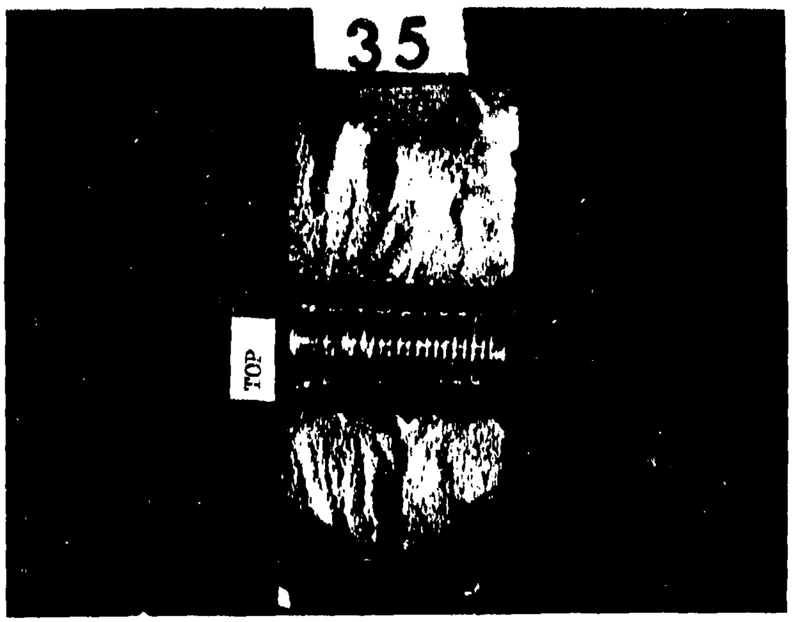


Figure 45. Close-up of Fatigue Failure of Specimens with Long-Lok 1/4-28 Size Inserts. Inserts Installed by Manufacture. No Bolts in Inserts.

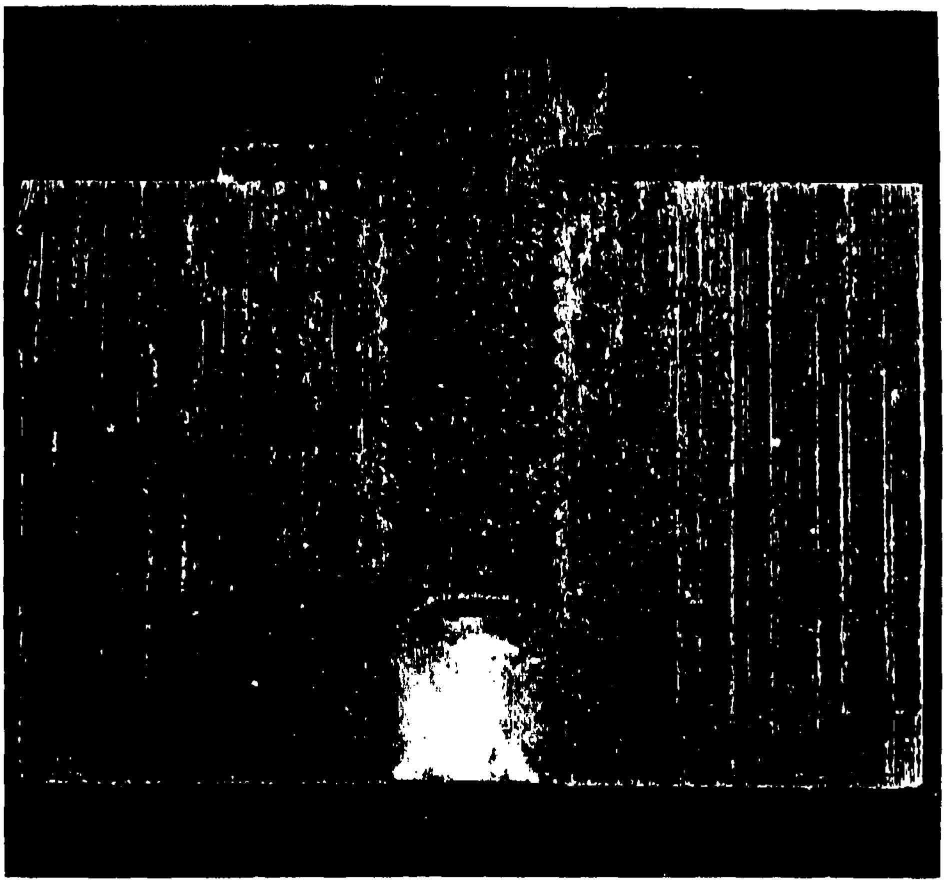


Figure 46. Corrosion Specimen with Washer and Bolt.

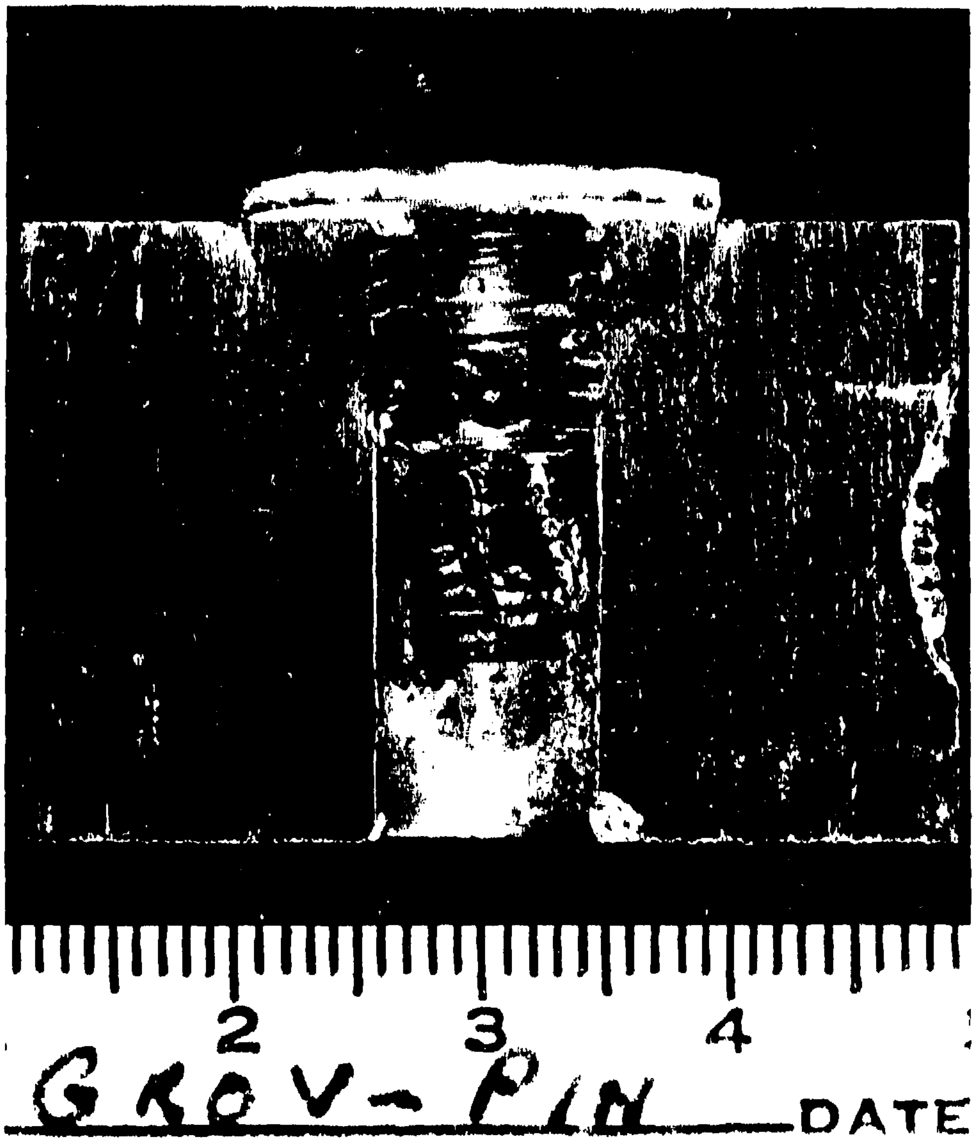


Figure 47. Corrosion Specimen

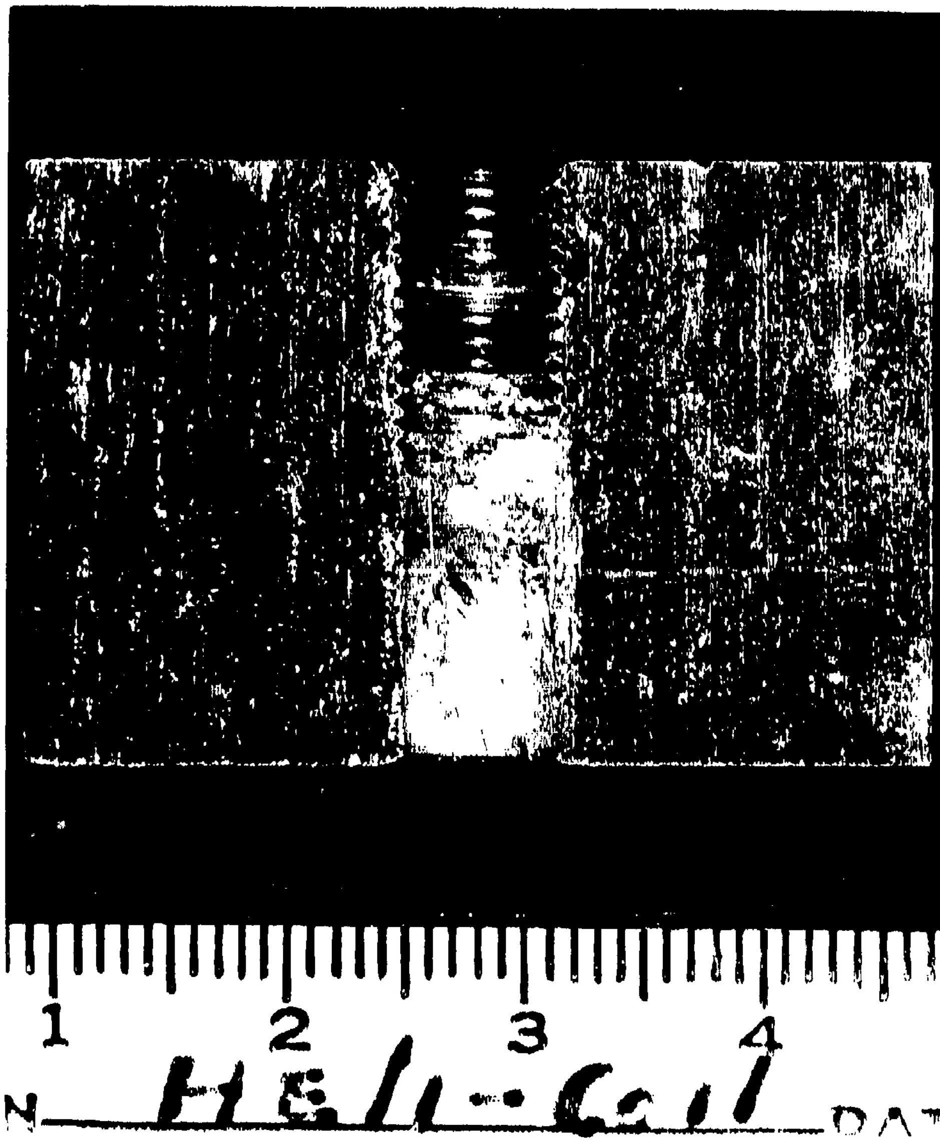


Figure 48. Corrosion Specimen

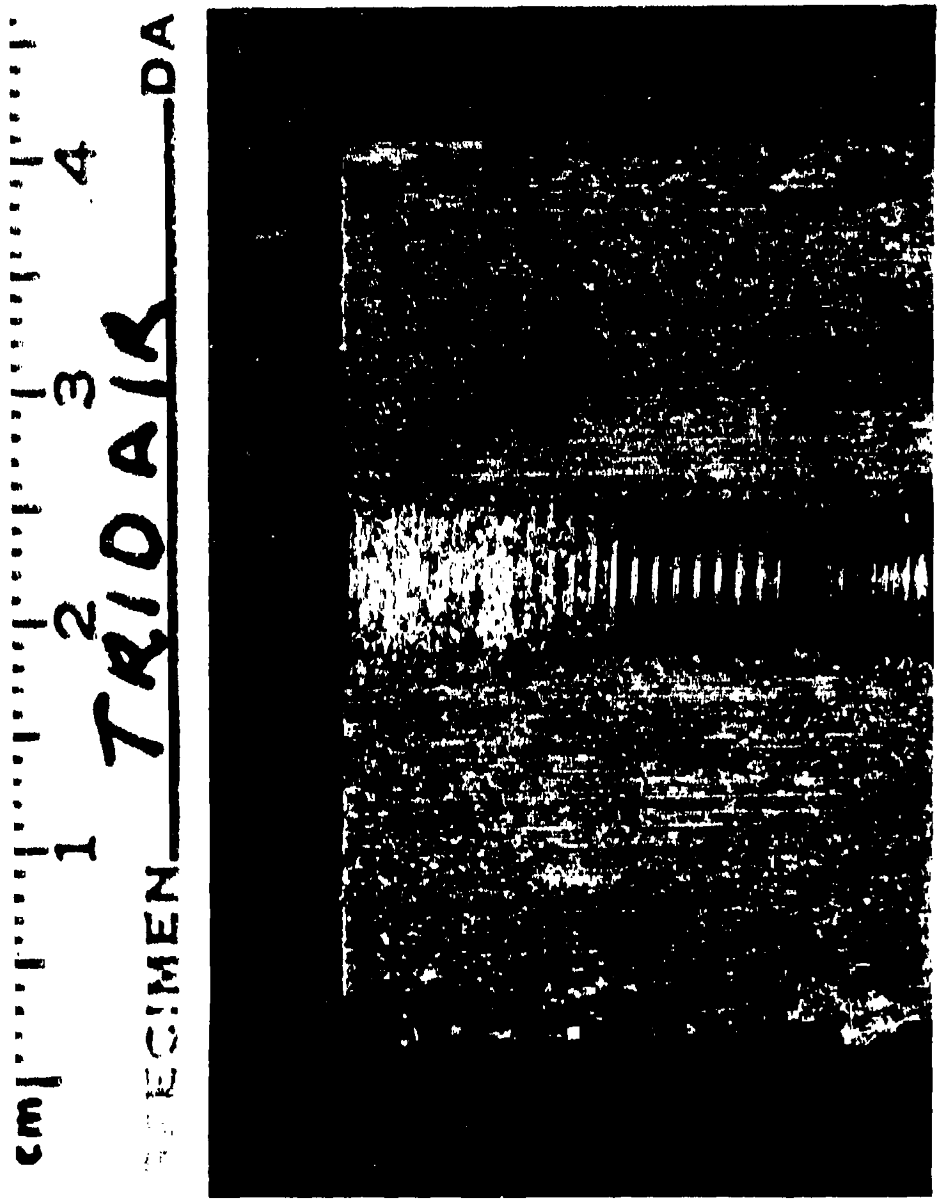


Figure 49. Corrosion Specimen

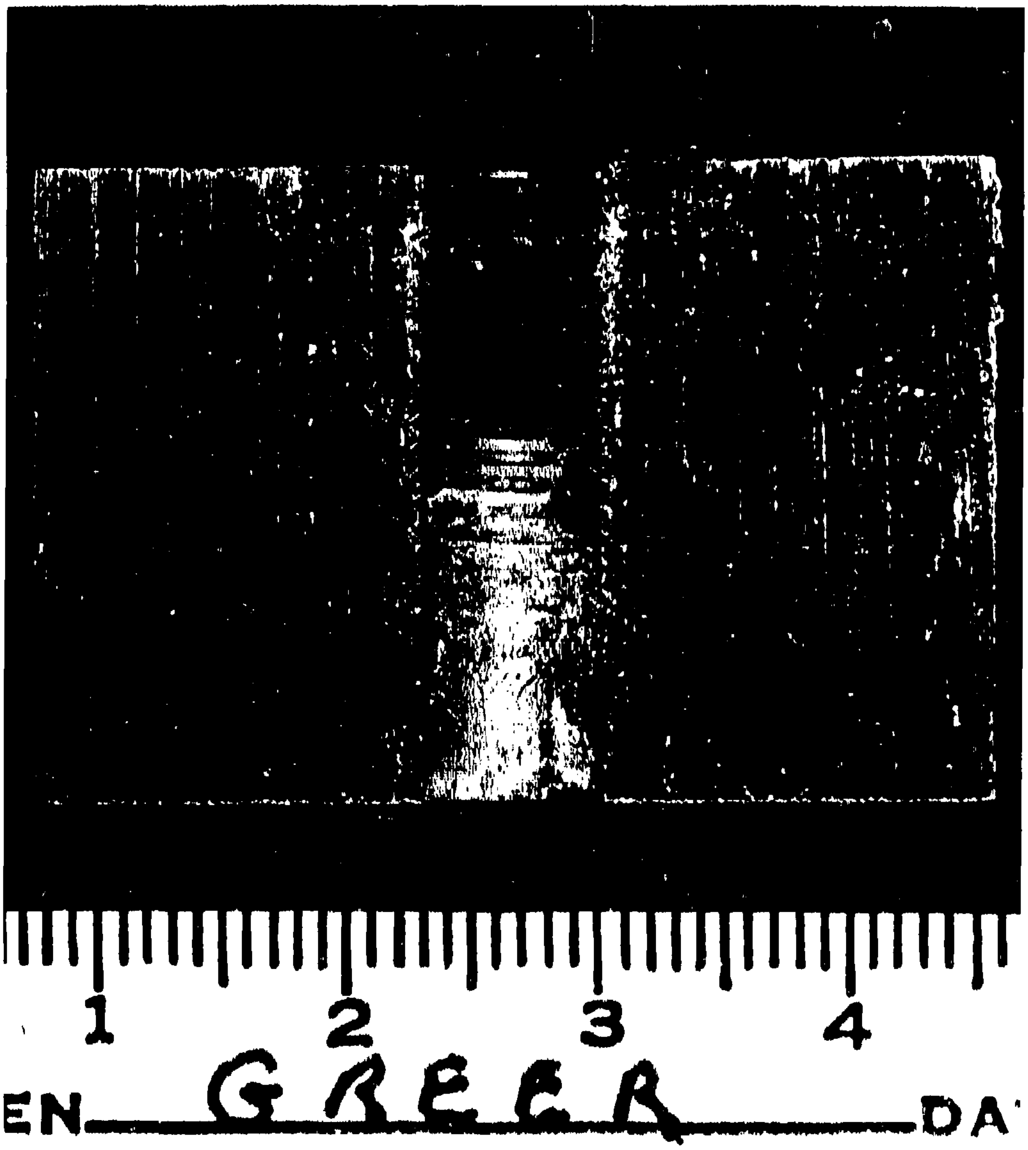


Figure 50. Corrosion Specimen

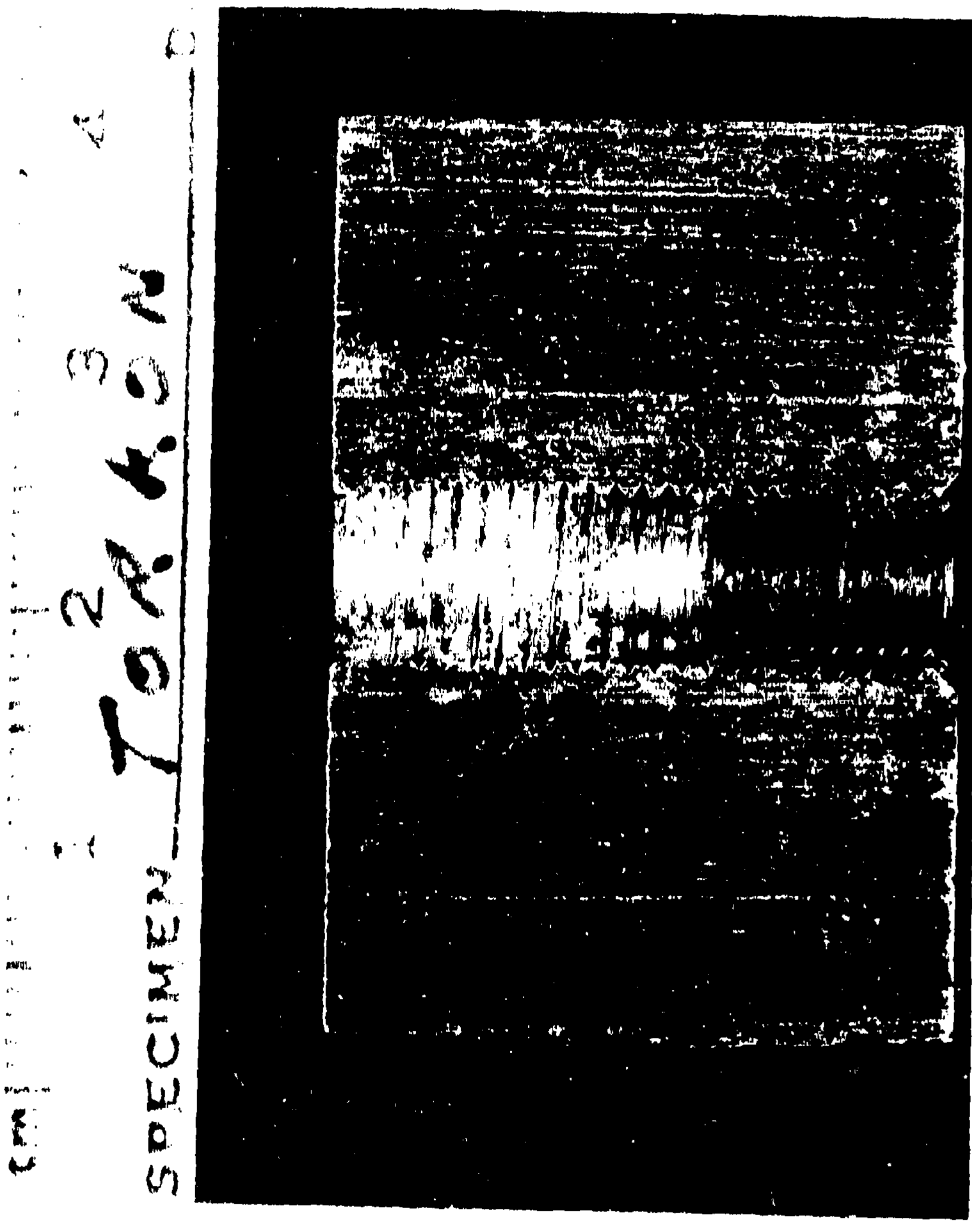


Figure 51. Corrosion Specimen

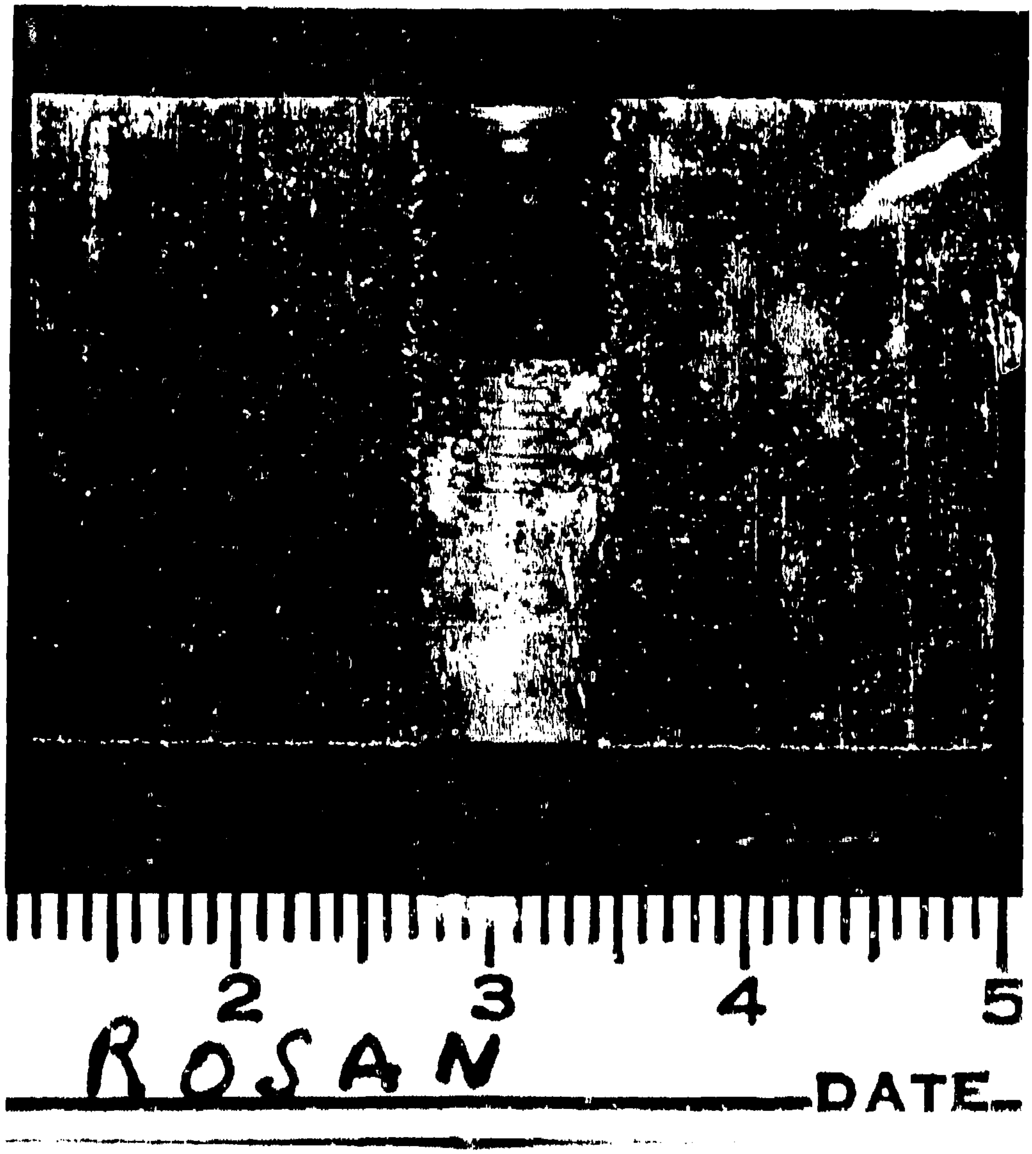


Figure 52. Corrosion Specimen

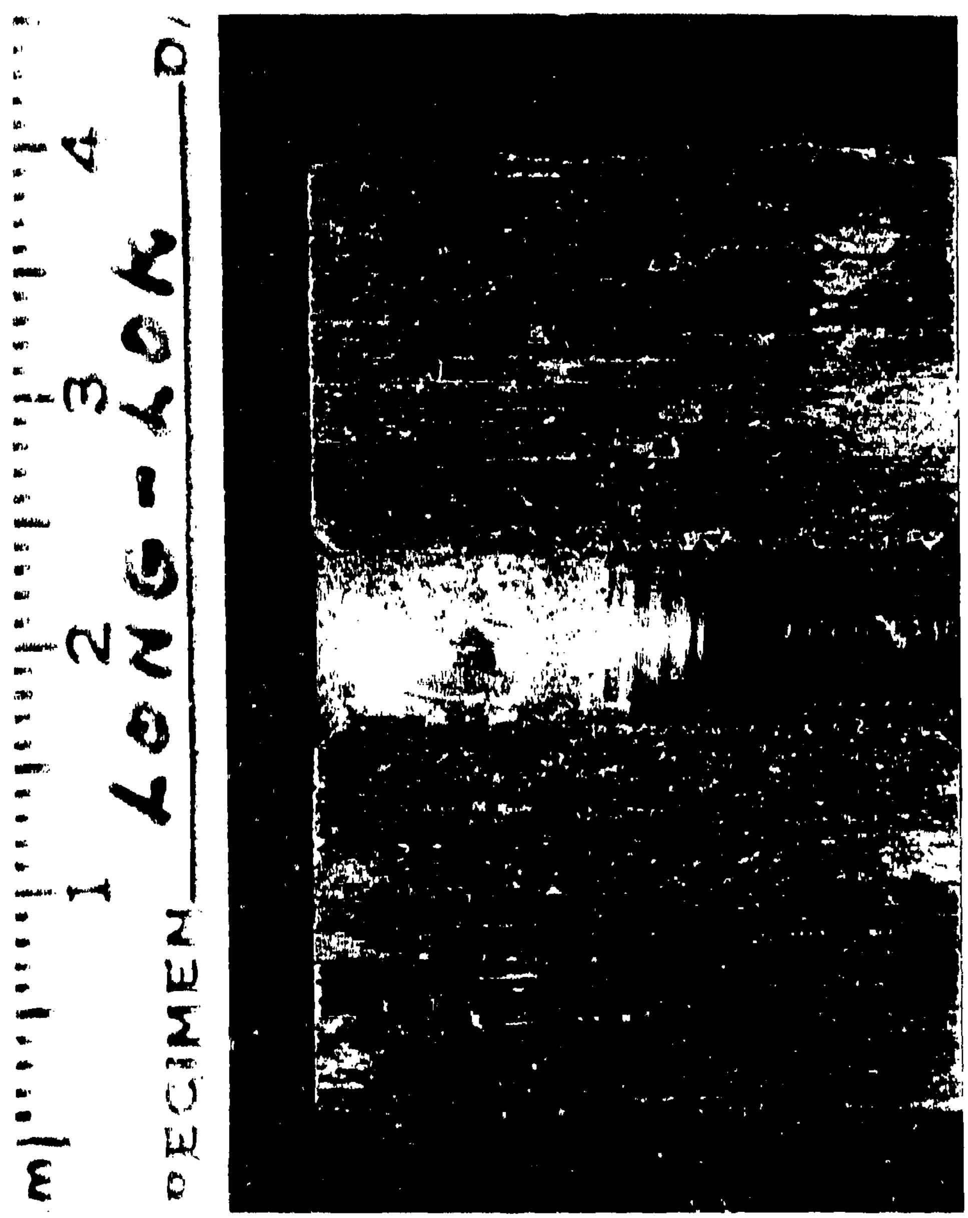


Figure 53. Corrosion Specimen

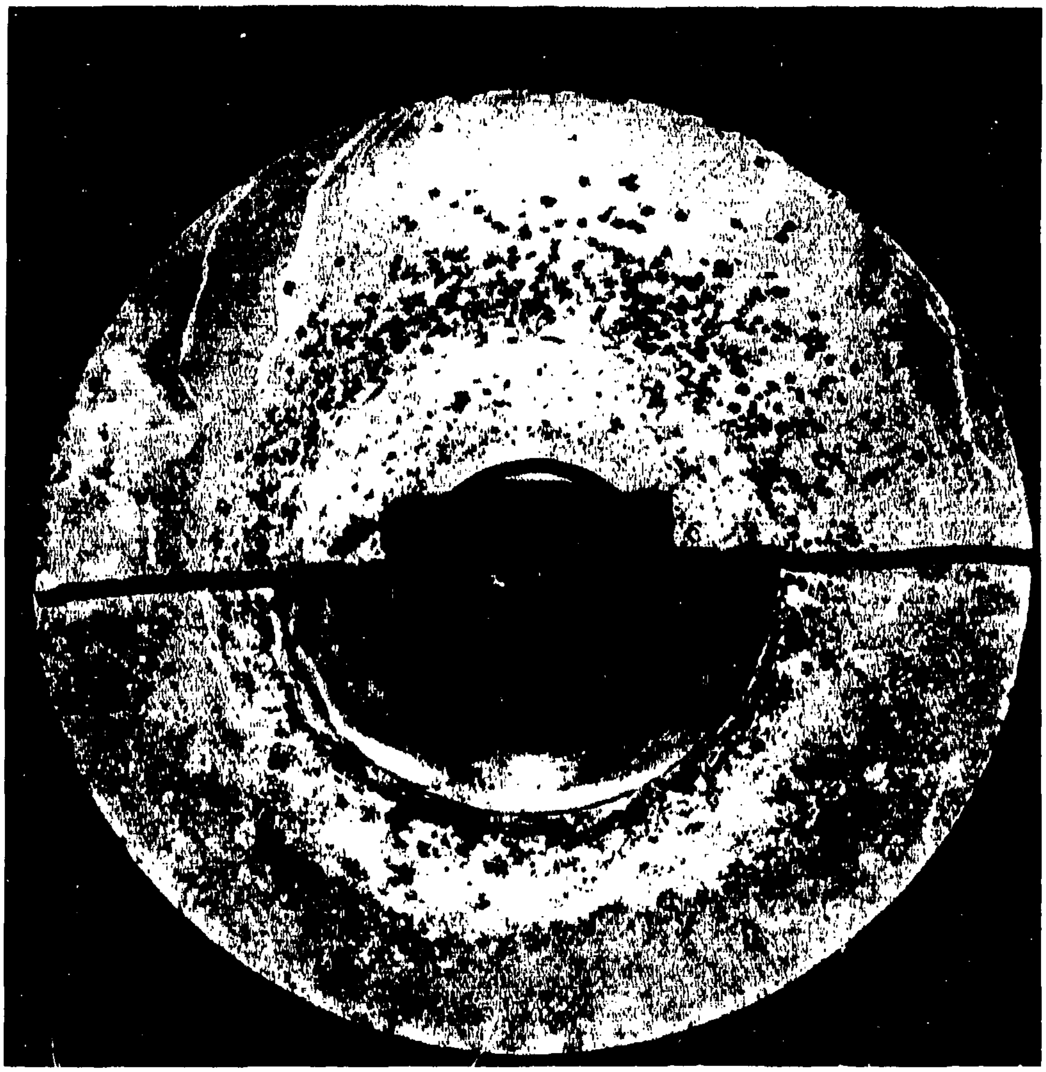


Figure 54. Corrosion of Parent Material Surface

Figure 55. Corrosion Specimen with Bolt Removed

Figure 56. Corrosion Specimen after Cleaning

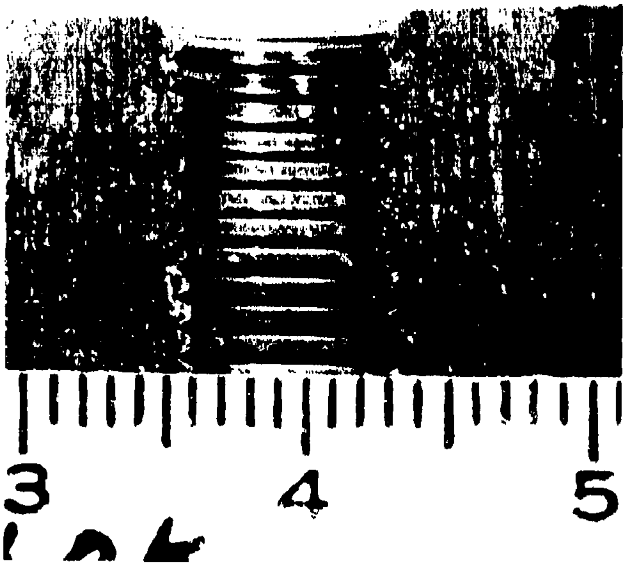


Figure 57. Corrosion Specimen after Cleaning

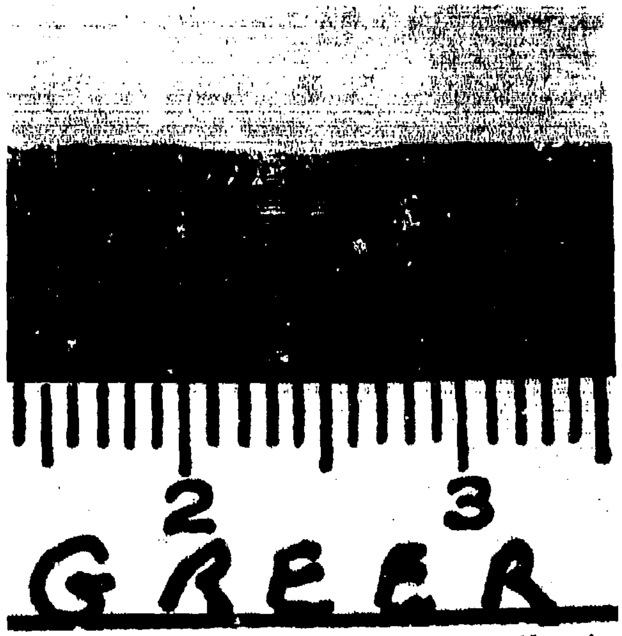


Figure 58. Corrosion Specimen after Cleaning

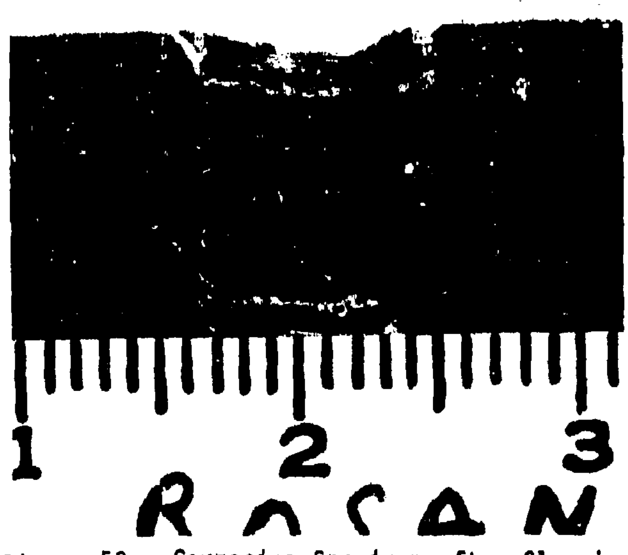


Figure 59. Corrosion Specimen after Cleaning

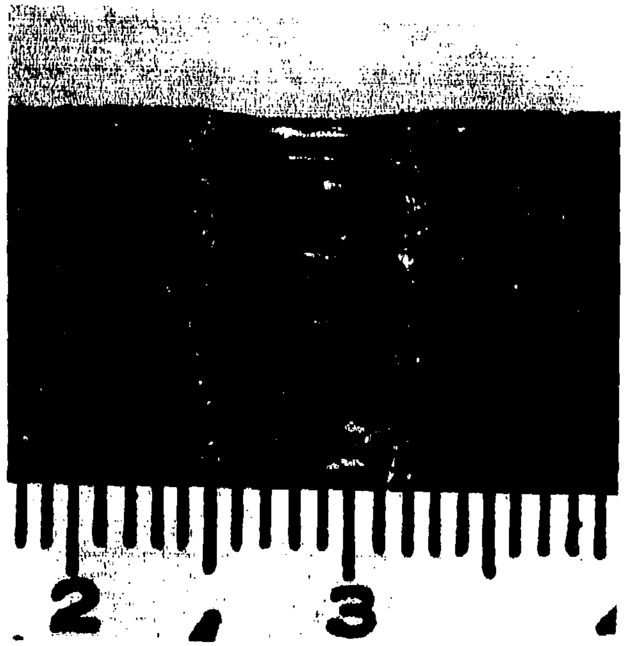


Figure 60. Corrosion Specimen after Cleaning

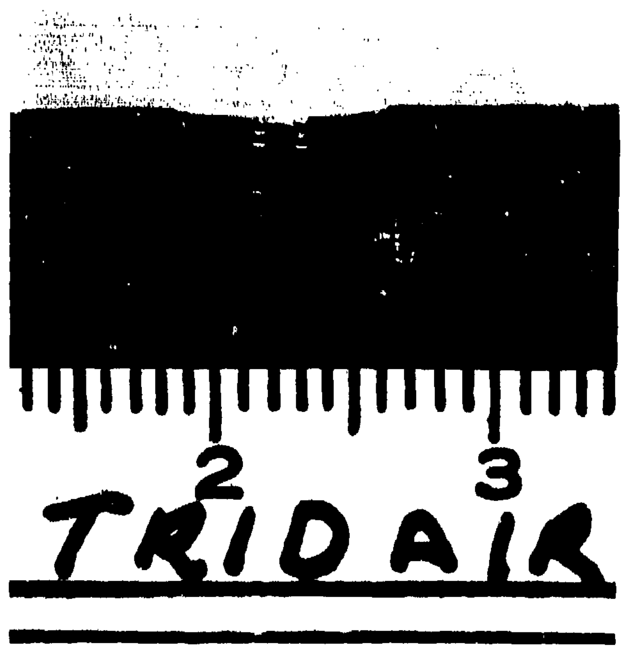


Figure 61. Corrosion Specimen after Cleaning

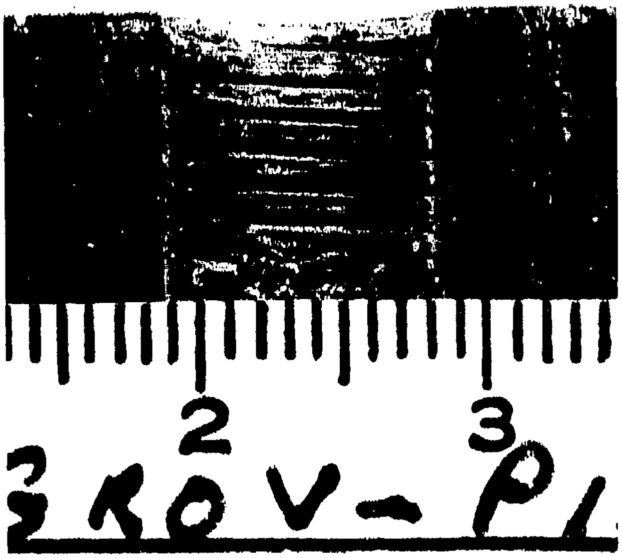


Figure 62. Corrosion Specimen after Cleaning

APPENDIX

INTRODUCTION

A statistical analysis of the engineering test data was made by the University of Dayton Research Institute. This analysis was undertaken to determine if there is a significant difference in the engineering test data obtained on threaded inserts supplied by several different insert manufacturers. Analysis of variance was used as the basic tool in the analysis of the experimental data.

SECTION 2

SUMMARY OF RESULTS

2.1 FATIGUE LIVES

Average fatigue lives for manufacturers displayed significant differences for each bolt size but the differences were not consistent over all three sizes. The installer (AFML or manufacturer) did not affect average fatigue life in the 10-32 and 1/4-28 bolt sizes but manufacturer installed inserts displayed larger average lives in the 3/8-24 bolts for some insert types. The fatigue lives with bolt inserted were significantly larger than those with inserts but no bolt. The average fatigue lives for inserts without bolts were not significantly different from specimens with hole but no insert installed.

2.2 BREAKAWAY TORQUE

In general, a larger breakaway torque is required to loosen the bolts after fatigue cycling than before. The difference in breakaway torque (before and after cycling) depends on the manufacturer and in the 1/4-28 bolts also depended on the installer.

2.3 AXIAL STRENGTHS

Average axial strengths displayed significant differences in the 1/4-28 and 3/8-24 size specimens. In the 1/4-28 sized specimens, the manufacturers could be divided into two strength groups with Rosan, Tridair, and Long-Lok having the greater average axial strength. In the 3/8-24 sized specimens, the Kaynar inserts had a smaller average strength than the others.

2.4 LOCKING AND BREAKAWAY TORQUE TESTS

The reduction in locking and breakaway torques after repeat bolt insertions averages approximately 35% at the 15th cycle. On the average about 64% of this reduction occurs during the first five cycles. Differences due to installers were small in comparison to differences due to specimen variation tested under identical conditions.

SECTION 3

STATISTICAL ANALYSIS

Data from three types of tests were subjected to statistical analyses. These were fatigue tests with the dependent variables of cycles to failure and breakaway torques after cyclic loading; axial strength tests; and the locking and breakaway torque tests. The analyses of the data from these three types of test are presented in the following paragraphs. Analysis of variance was used as the basic tool in the analysis of the experimental data. The fatigue life tests on 1/4-28 size bolts will be presented in detail to show the application of the analysis of variance technique to experimental data.

3.1 FATIGUE TESTS

Two types of data were collected for analysis during the fatigue tests: number of cycles to failure and breakaway torque before and after fatigue cycling.

3.1.1 Life Tests

The objective of the analysis of the fatigue life data was to ascertain if significant results were obtained from the different manufacturers; from the different installers; and from the specimens without inserts, the specimens with inserts only, and the specimens with inserts and bolts. To test these hypotheses constant amplitude fatigue tests were run at R = 0.1 and maximum stress of 50% of ultimate for each of three specimen thicknesses (bolt sizes). Note that each specimen contains three inserts and the fatigue test terminated at the failure of any one of the three. The location within the specimens of the failing insert occurred at random among the three possible locations. For the 10-32 and 3/8-24 bolt size specimens, the fatigue tests were only conducted with bolts inserted. For the 1/4-28 size, specimens were tested with and without bolts and some specimens were also tested without inserts (smooth and threaded). For each manufacturer-size combination half of the inserts were installed by the manufacturer and half by the AFML. Since all combinations of the experimental conditions were tested for a bolt size, the data comprise of factorial experiment.

Table 59 presents the data layout for the 1/4-28 bolt size fatigue tests when viewed in factorial format. (Since this data is simply a rearrangement of the data in Tables 26-33 similar tables for the other experiments will not be presented.) The statistical model for the analysis of the data of Table 59 is given by

$$Y_{ijkl} = \mu + M_i + I_j + MI_{ij} + B_k + MB_{ik} + IB_{jk} + MIB_{ijk} + \epsilon_{ijkl}$$

where:

Y_{ijkl} = observed cycles to failure

μ = overall average

M_i = differential effect of manufacturer i

I_j = differential effect of installer i (AFML or MFG)

MI_{ij} = differential joint effect of M_i and I_j

B_k = differential effect due to presence or absence of bolt

MB_{ik} = differential joint effect of M_i and B_k

IB_{jk} = differential joint effect of I_j and B_k

MIB_{ijk} = differential joint effect of M_i, I_j, and B_k

ϵ_{ijkl} = random error for the lth replication of the experimental condition defined by M_i, I_j, and B_k.

It is assumed that ϵ_{ijkl} are independent, normally distributed random variables with zero mean and common variance, σ^2. All uncontrolled sources of variation in the experiment are measured in the estimate of σ^2. The analysis of variance (as applied here) is a technique for testing whether the differential effects are significantly different from zero. For example, if the installer does not affect fatigue life, the differential effect due to installer should be zero and the I terms can be eliminated from the model. For those differential effects which are significantly different from zero, further statistical tests, based on the estimate of σ (the standard error) are available to identify specific significant differences. The analysis of variance results for an experiment are summarized in an analysis of variance table. Table 60 summarizes the analysis of variance for the data of Table 59. In these experiments the F ratio is the ratio of the mean square for a source of variation to the random error mean square. Large F ratios indicate significant effects where largeness is defined by degrees of freedom and level of significance desired for the tests and can be ascertained from tables in most texts on statistics. For these experiments, the level of significance (the probability of rejecting the null hypothesis when true) was fixed at 0.05. Thus, it was concluded that the presence or absence of the bolt significantly affects fatigue life and that the fatigue lives from the different manufacturers are significantly different. The effect due to installer was not significant. Figure 63 plots average life for each manufacturer by bolt combination with 95% confidence limits for the mean lives with bolt inserted. The average life for the Heli-Coil inserts with bolts were significantly longer than those of the Torkon and Groov-Pin. The other differences among the average lives with bolts were not significant.

Three hole conditions were fatigue tested without inserts (Table 25). An analysis of variance indicated that there were no significant differences between average lives of the smooth and threaded holes. The composite average of all 15 specimens was 31,400 cycles with a standard deviation of 4,180 cycles. Thus, 95% confidence limits on mean life without inserts are given by the interval $31{,}400 \pm t_{0.95,14}(4180)/\sqrt{14}$

or (29000, 33,800). Since the composite average of the fatigue lives with insert only was 31,600 cycles, there was not a significant difference between the specimens with and without inserts.

In the fatigue tests of the 10-32 and 3/8-24 bolt sizes, all tests were performed with bolts. The analysis of these data could only evaluate the manufacturers and the installers.

Table 61 presents the analysis of variance table for the 10-32 bolt size experiment. The only significant effect was that due to the manufacturer. Figure 64 presents the average life for each manufacturer with 95% confidence limits. The Heli-Coil inserts had significantly longer average life than all except the Groov-Pin inserts for this bolt length. The Groov-Pin average life was significantly longer than all except the Tridair insert . The Torkon insert had a significantly shorter average life than all other inserts for this bolt size.

The analysis of variance table for the 3/8-24 bolt sizes is presented in Table 62. For this bolt size, significant differences existed among the manufacturers, between the installers, and the differences due to installers were not consistent among the different insert manufacturers. Average life for each combination of installer and manufacturer is presented in Figure 65. For the Rosan, Tridair, and Groov-Pin inserts the manufacturer installed specimens had longer average lives than the AFML specimens. The differences in average life between manufacturer and AFML installed specimens were not significant for the other brands of inserts. The manufacturer installed specimens had significantly longer average lives than the AFML installed specimens. Specific comparisons between any manufacturer-installer pair can be made by declaring the average difference statistically significant (at the 95 percent level of confidence) if it exceeds 8.4K cycles.

3.1.2 Breakaway Torques After Cyclic Loading

To determine if cyclic loading had a significant effect on breakaway torque, measurements were taken on all inserts before the fatigue tests and on the unfailed inserts at the conclusion of the fatigue test (Tables 3 through 23). The difference between the after fatigue cycling breakaway torque and the before from the unfailed inserts provided the measure which was used in the analysis of these data. For each bolt size, the torque differences were analyzed for differences due to insert manufacturers or insert installers and whether or not significantly more torque was required after cyclic loading.

Table 63 presents the analysis of variance table for the breakaway torque differences measured on the 10-32 specimens. The average differences due to manufacturers contained significant differences but the average differences did not depend on installers. Figure 66 displays the average difference for each manufacturer with 95 percent confidence limits for the means. The average differences in breakaway torques were significantly less for the Kaynar and Rosan inserts than for the others. Further, the differences in breakaway torques between before and after fatigue testing were not significantly different for the Kaynar and Rosan inserts but the others required greater torque after fatigue cycling.

The analysis of variance table for the differences in breakaway torque of 1/4-28 size bolt fatigue tests is presented in Table 64. For these data the manufacturer and joint manufacturer by installer effect were significant. The average before minus after torque measurement for the manufacturer by installer combinations are presented in Figure 67. For these bolt size specimens, the AFML installed Rosan inserts required significantly greater breakaway after fatigue cycling than did the manufacturer installed Rosan inserts. The Kaynar, Long-Lok, Torkon, and AFML installed Groov-Pin Rosan installed inserts required equivalent torques before and after fatigue cycling.

The analysis of variance table for the 3/8-24 bolt size breakaway torque bolt differences is presented in Table 65. The difference between manufacturers and installers are not statistically significant for this bolt size specimen. Note, however, that these data exhibited significantly more variability (larger standard error) than did those of the torque differences in the narrower specimens. Figure 68 presents average difference for each manufacturer (with confidence limits) even though the manufacturer differences are not significant. Note that for all manufacturers significantly greater breakaway torque was required after fatigue cycling than before.

5.2 AXIAL STRENGTH TESTS

Tensile strength pull out tests were conducted in accordance with the factorial experiment which permits comparison of axial strengths for the insert manufacturers and installers for each of the three specimen thicknesses (Table 35). This section presents the analyses of these data.

Table 66 contains the analysis of variance table for the axial strength tests of the 10-32 size specimens. There were no differences in average strength among the manufacturers or between the installers. However, differences between installer-manufacturer average strength combinations for the Kaynar and Groov-Pin inserts as compared to the Long-Lok inserts produced a significant joint effect. This can be seen in the plot of average strengths for manufacturer-installer combinations of Figure 69. Note that the differences in the average strengths for the installers of any one insert are not significant.

The analysis of variance table for the 1/4-28 axial strength tests is presented in Table 67. Only the manufacturer effect was significant and average strengths for each manufacturer with 95 percent confidence limits is presented in Figure 70. The 1/4-28 inserts from Rosan, Tridair, and Long-Lok had significantly greater average strengths than the others.

Table 68 presents the analysis of variance table for the axial strength tests in 3/8-24 size specimens. The manufacturer-installer joint effect was significant as well as the differences in average strengths among the manufacturers. Figure 71 presents average axial strengths for these thick specimens. The Kaynar insert specimens had significantly less average strength than the others while the Torkon specimens, manufacturer installed displayed significantly greater strength than the other combinations. The joint effect is due to the greater average strengths for the Torkon and Groov-Pin inserts when installed by the manufacturer than by AFML while the Kaynar AFML installed inserts had greater strength than the Kaynar installed inserts.

3.3 LOCKING AND BREAKAWAY TORQUE TESTS

To investigate the wear resulting from repeated engagement of bolts in the fasteners, three inserts from each manufacturer-installer-bolt size combination were cycled through 15 engagements and disengagements of bolts. The resulting data (Tables 43-57) displayed minor differences between installers as compared to sample variation of replicate conditions. Figures 72 through 78 display average torque for each cycle of each manufacturer by bolt size combination. At the 15th cycle, locking and unlocking torques are reduced by an average of 36 percent of their orginal values (first cycle). As can be seen on the figures, much of this reduction generally occurs during the first few cycles. Table 69 presents the percent reduction of average torques for each manufacturer-bolt size combination at the 5th, 10th, and 15th cycle.

TABLE 59

FATIGUE LIVES FROM 1/4-28 TESTS

(K Cycles to Failure)

		Manufacturer						
		KAY	ROS	HC	TRI	LL	TOR	GP
With Bolt	AFML	49.5	43.2	43.4	45.9	39.9	37.6	40.7
		39.8	39.0	46.4	45.3	52.8	38.5	29.1
		33.6	61.2	58.9	47.1	52.1	35.9	39.0
	MFG	43.6	48.1	43.5	37.4	41.8	35.9	45.4
		33.0	36.9	53.8	52.8	34.8	37.3	24.7
		45.5	50.2	49.5	44.3	33.7	37.5	32.9
Without Bolt	AFML	24.3	32.7	30.0	41.4	28.6	29.0	25.7
		32.4	33.5	25.5	33.5	37.7	28.2	29.5
		31.1	31.3	35.9	31.5	30.2	27.8	22.8
	MFG	27.4	50.3	34.5	27.8	31.7	26.5	25.4
		44.1	30.5	32.1	38.3	29.5	24.1	29.3
		35.0	50.8	39.6	35.1	28.0	24.4	27.2

TABLE 60

ANALYSIS OF VARIANCE TABLE FOR FATIGUE
LIVES FROM 1/4-28 TESTS

Source of Variation	Degrees of Freedom	Mean Square	F Ratio	
Manufacturer (M)	6	217.20	6.14	Significant
Installers (I)	1	0.63	0.02	
MI	6	41.83	1.18	
Bolt (B)	1	2489.56	70.34	Significant
MB	6	27.37	0.77	
IB	1	108.12	3.06	
MIB	6	25.68	0.73	
Random error	56	35.39		
Total	83			

Standard error = $\sqrt{35.39}$ = 5.95 (K cycles)

TABLE 61

ANALYSIS OF VARIANCE TABLE FOR FATIGUE
LIVES FROM 10-32 TESTS

Source of Variation	Degrees of Freedom	Mean Square	F Ratio	
Manufacturer	6	881.8	15.3	Significant
Installer	1	89.2	1.55	
MI	6	43.8	0.76	
Random error	28	57.6		
Total	41			

Standard error = $\sqrt{57.6}$ = 7.59 (K cycles)

TABLE 62

ANALYSIS OF VARIANCE TABLE FOR FATIGUE LIVES FROM 3/8-24 TESTS

Source of Variation	Degrees of Freedom	Mean Square	F Ratio	
Manufacturer	6	177.5	9.76	Significant
Installer	1	174.0	9.57	Significant
MI	6	109.3	6.01	Significant
Random error	28	18.19		
Total	41			

Standard error = $\sqrt{18.19}$ = 4.27 (K cycles)

TABLE 63

ANALYSIS OF VARIANCE TABLE FOR BREAKAWAY TORQUE DIFFERENCES - 10-32 FATIGUE TESTS

Source of Variation	Degrees of Freedom	Mean Square	F Ratio	
Manufacturer	6	170.4	3.94	Significant
Installer	1	136.3	3.15	
MI	6	60.4	1.39	
Random error	70	43.3		
Total	83			

Standard error = $\sqrt{43.3}$ = 6.6 in.-lbs.

TABLE 64

ANALYSIS OF VARIANCE TABLE FOR BREAKAWAY TORQUE DIFFERENCES - 1/4-28 FATIGUE TESTS

Source of Variation	Degrees of Freedom	Mean Square	F Ratio	
Manufacturer	6	1311.6	11.12	Significant
Installer	1	5.79	0.05	
MI	6	386.4	3.28	Significant
Random error	68	117.9		
Total	81			

Standard error = $\sqrt{117.9}$ = 10.86 in.-lbs.

TABLE 65

ANALYSIS OF VARIANCE TABLE FOR BREAKAWAY TORQUE DIFFERENCES - 3/8-24 FATIGUE TESTS

Source of Variation	Degrees of Freedom	Mean Square	F Ratio	
Manufacturer	6	6031.2	1.86	
Installer	1	106.1	0.03	
MI	6	6584.5	2.03	
Random error	68	3245.1		
Total	81			

Standard error = $\sqrt{3245.1}$ = 57.0 in.-lbs.

TABLE 66

ANALYSIS OF VARIANCE TABLE FOR AXIAL STRENGTH - 10-32 SIZE SPECIMENS

Source of Variation	Degrees of Freedom	Mean Square	F Ratio	
Manufacturer	6	67,000	0.70	
Installer	1	191,000	2.00	
MI	6	310,000	3.25	Significant
Random error	28	95,000		
Total	41			

Standard error = $\sqrt{95000}$ = 308 lbs.

TABLE 67

ANALYSIS OF VARIANCE TABLE FOR AXIAL STRENGTH - 1/4-28 SIZE SPECIMENS

Source of Variation	Degrees of Freedom	Mean Square	F Ratio	
Manufacturer	6	4,267,000	15.13	Significant
Installer	1	144,000	0.51	
MI	6	117,000	0.41	
Random error	28	282,000		
Total	41			

Standard error = $\sqrt{282000}$ = 530 lbs.

TABLE 68

ANALYSIS OF VARIANCE TABLE FOR AXIAL STRENGTH - 3/8-24 SIZE SPECIMENS

Source of Variation	Degrees of Freedom	Mean Square	F Ratio	
Manufacturer	6	31,942,000	34.16	Significant
Installer	1	3,691,000	3.94	
MI	6	5,884,000	6.29	Significant
Random error	28	935,000		
Total	41			

Standard error = $\sqrt{935000}$ = 967 lbs.

TABLE 69

PERCENT REDUCTION OF AVERAGE LOCKING AND BREAKAWAY TORQUES

Size	Manufacturer	Cycle 5	Cycle 10	Cycle 15
10-32	Kaynar	18	28	28
	Rosan	23	39	41
	Heli-Coil	28	29	31
	Tridair	40	33	39
	Long-Lok	21	31	33
	Torkon	22	29	41
	Groov-Pin	37	48	49
1/4-28	Kaynar	17	20	23
	Rosan	18	23	23
	Heli-Coil	24	32	36
	Tridair	5	10	11
	Long-Lok	15	22	26
	Torkon	28	42	45
	Groov-Pin	40	41	45
3/8-24	Kaynar	21	27	32
	Rosan	7	11	11
	Heli-Coil	21	35	42
	Tridair	25	39	42
	Long-Lok	12	26	36
	Torkon	26	40	46
	Groov-Pin	40	67	69

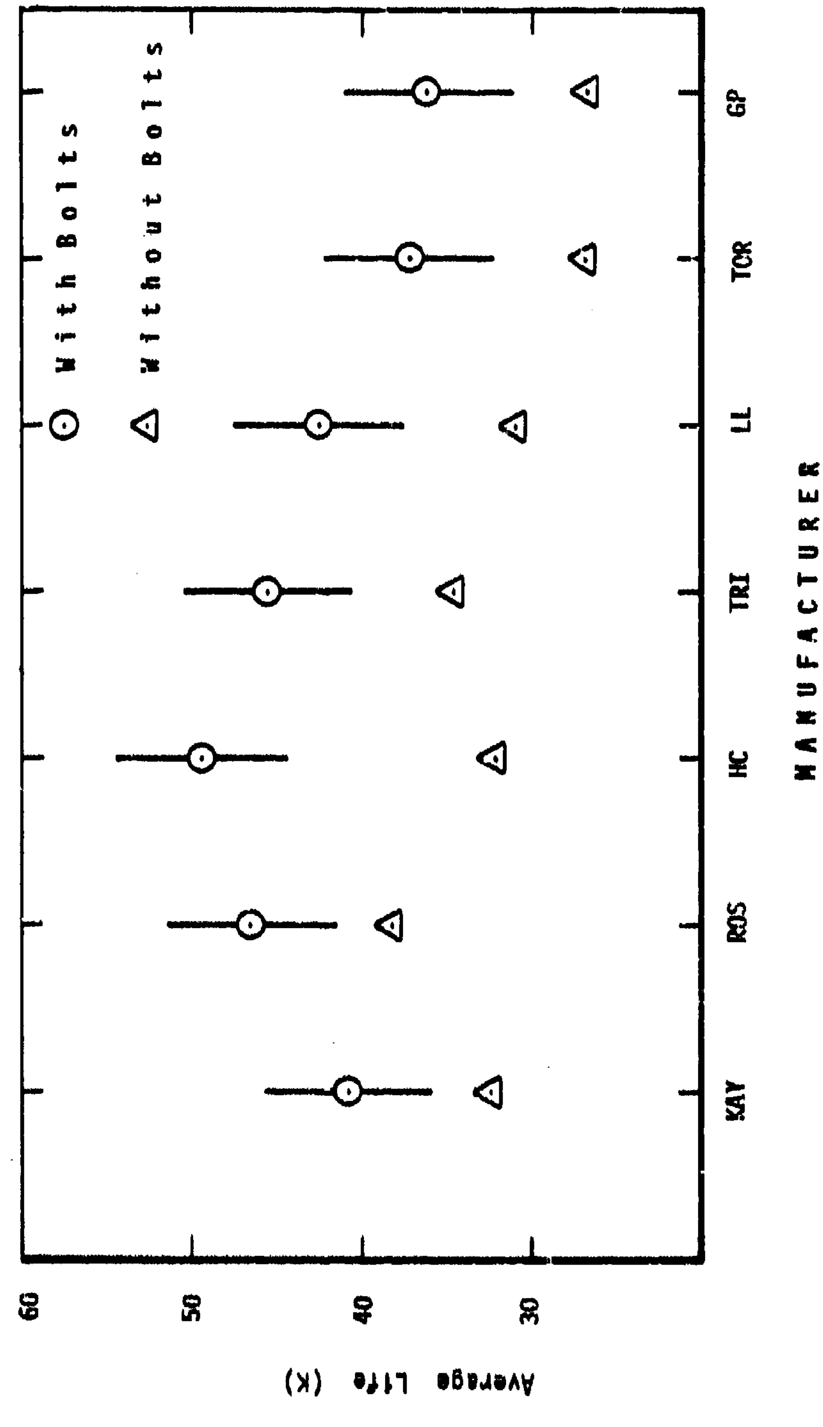


Figure 63. Average Life for Manufacturers - 1/4-28 Tests

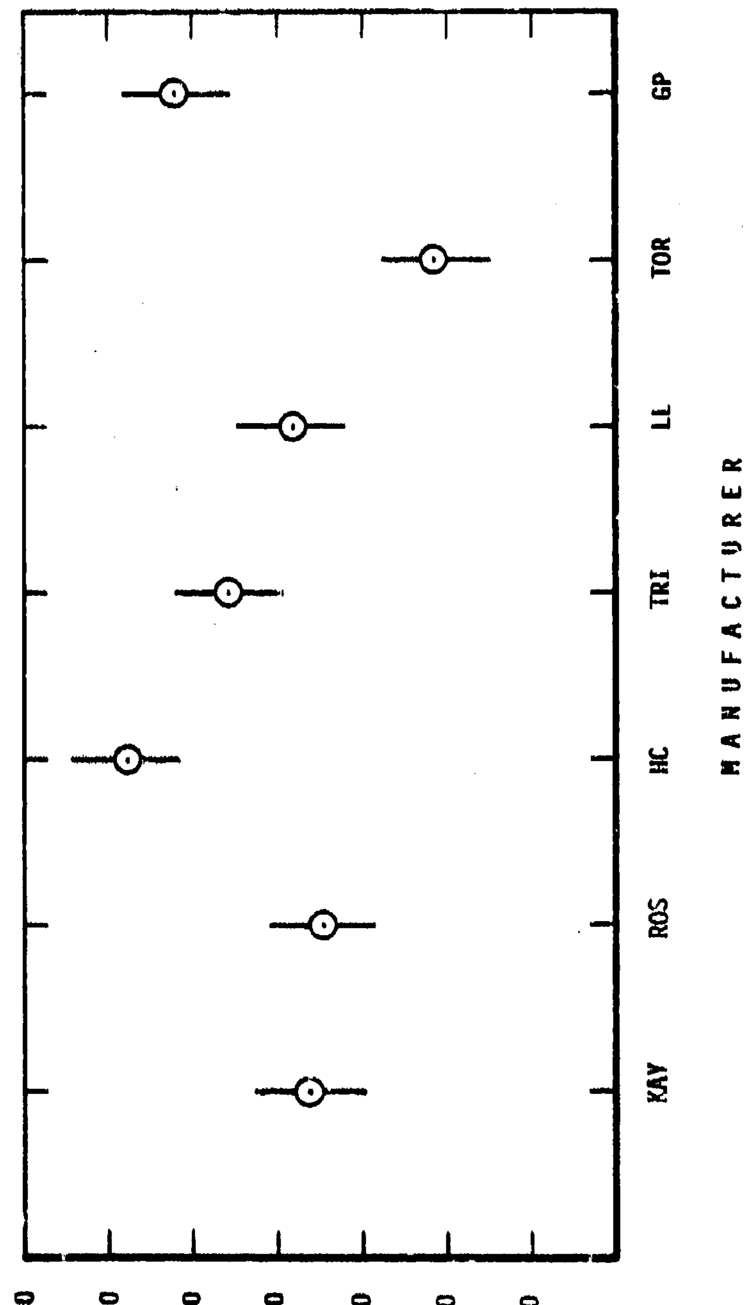


Figure 64. Average Life for Manufacturers - 10-32 Tests

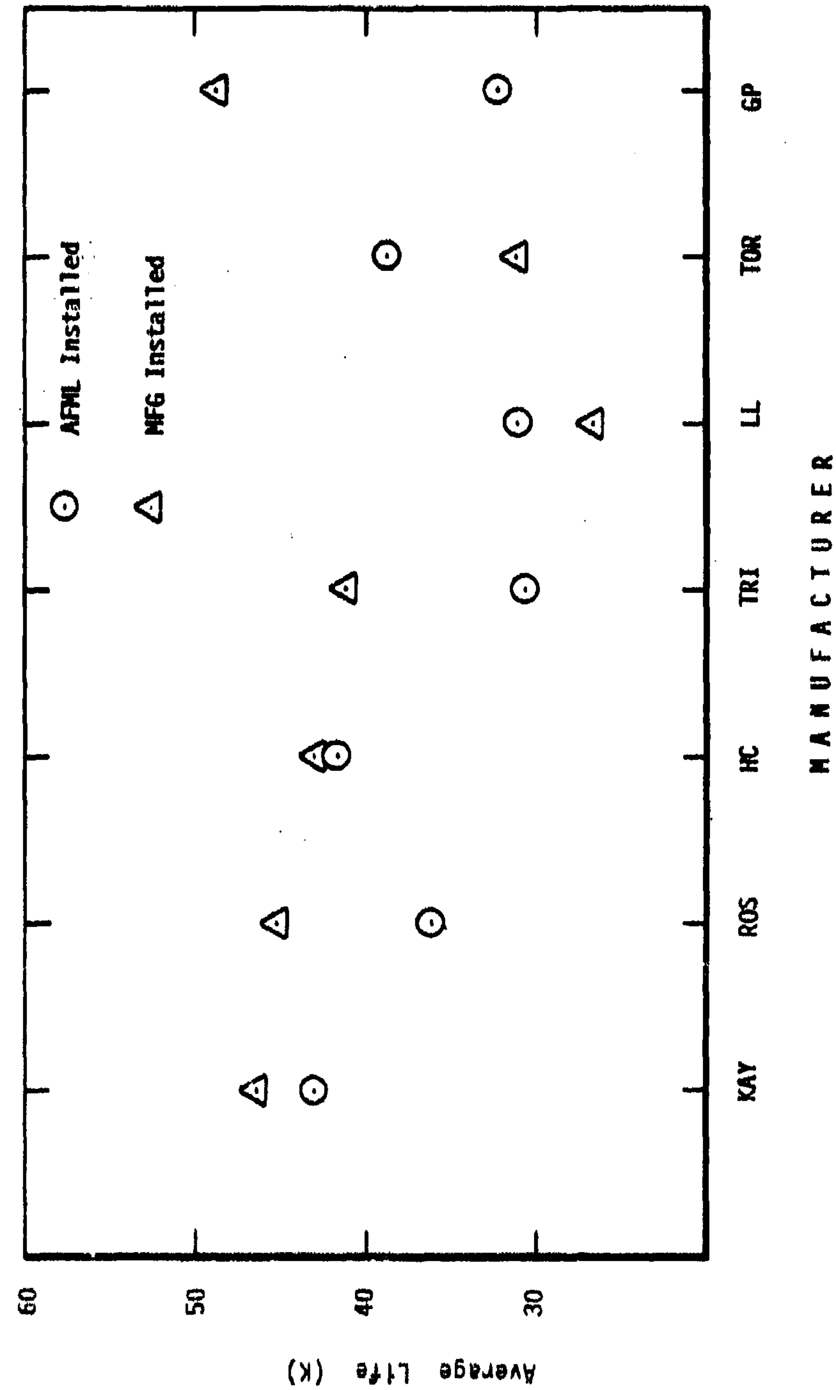


Figure 65. Average Life for Manufacturers - 3/8-24 Tests

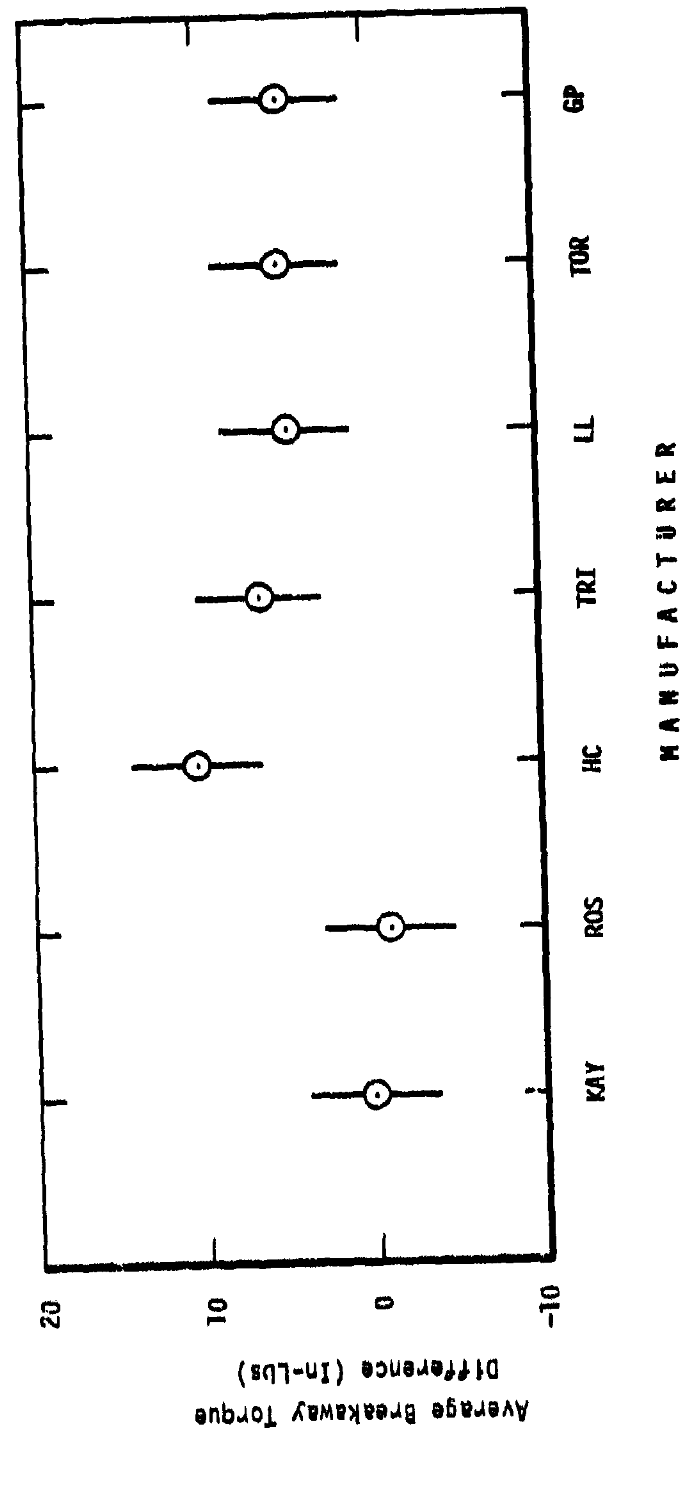


Figure 66. Average Breakaway Torque Differences - 10-32 Fatigue Tests

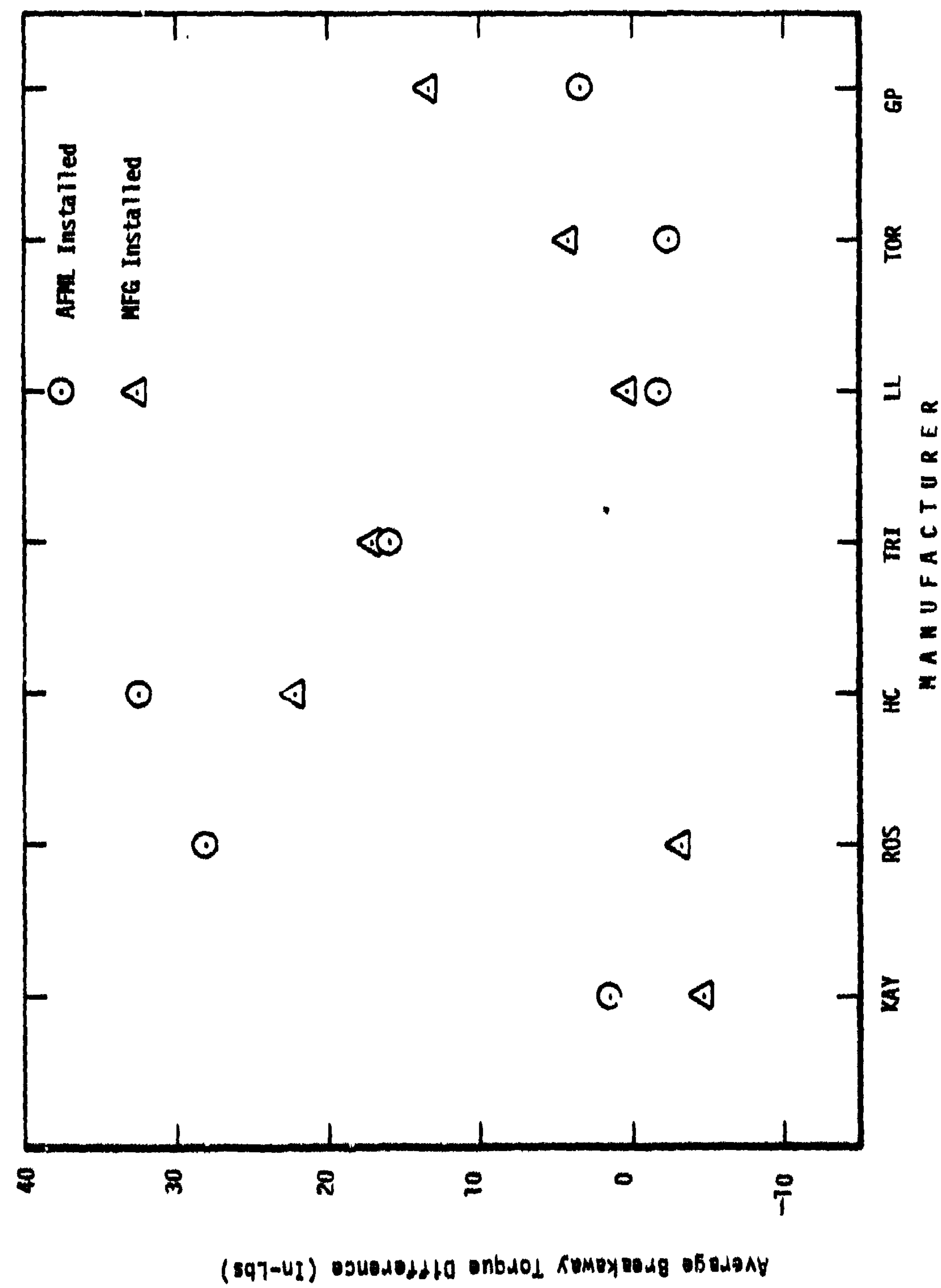


Figure 67. Average Breakaway Torque Differences - 1/4-28 Fatigue Tests

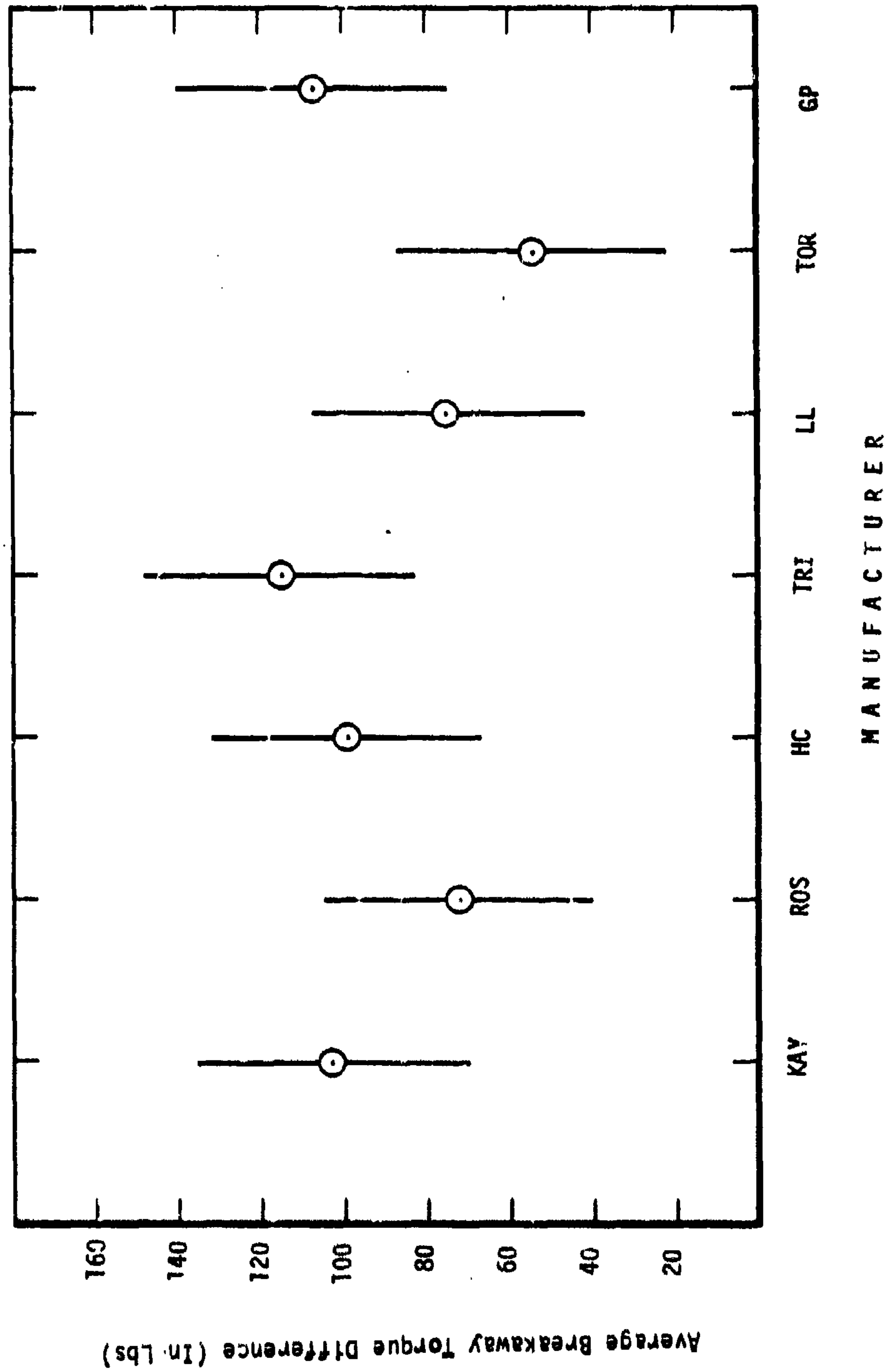


Figure 68. Average Breakaway Torque Differences - 3/8-24 Fatigue Tests

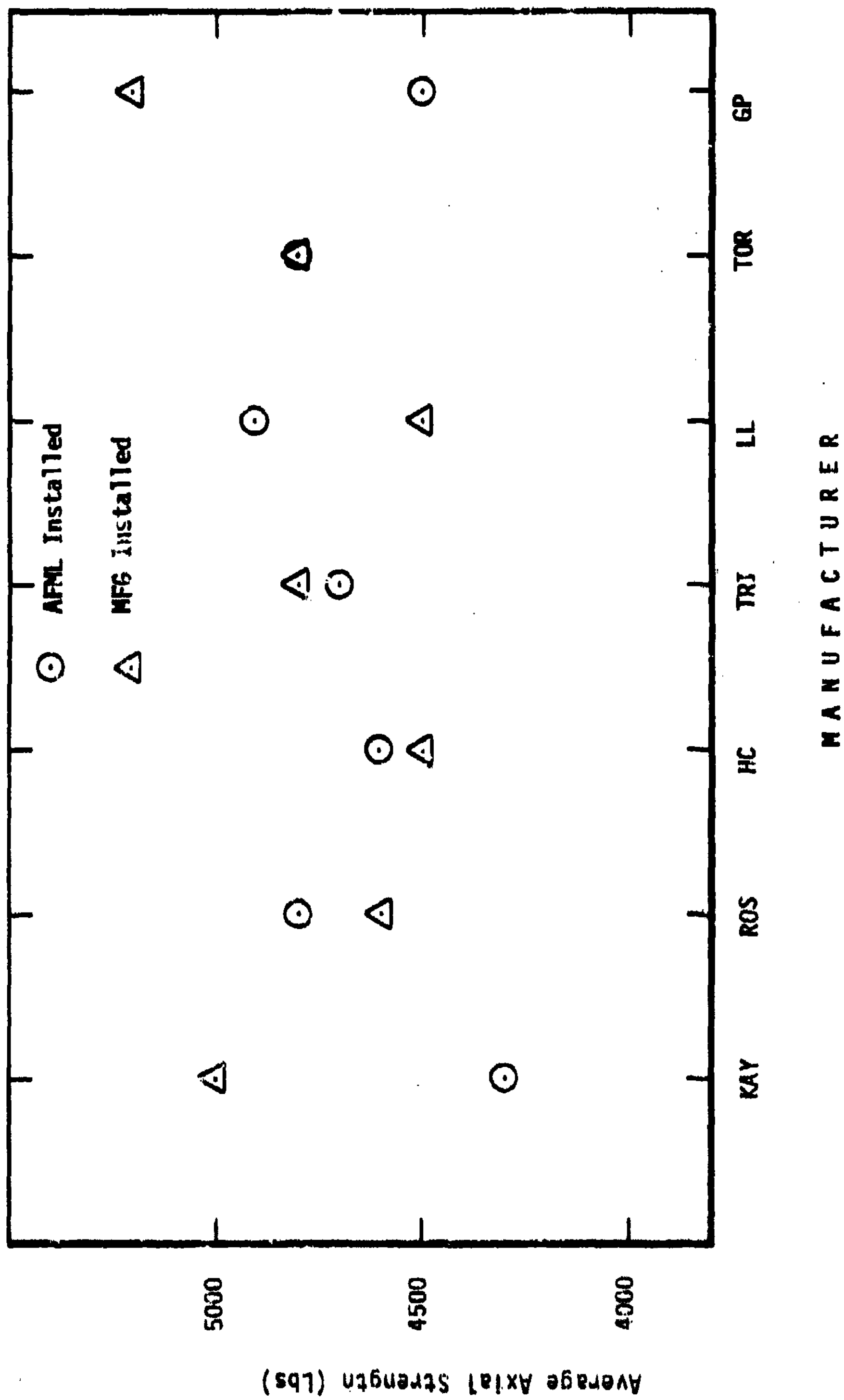


Figure 65. Average Axial Strengths - 10-32 Size Specimens

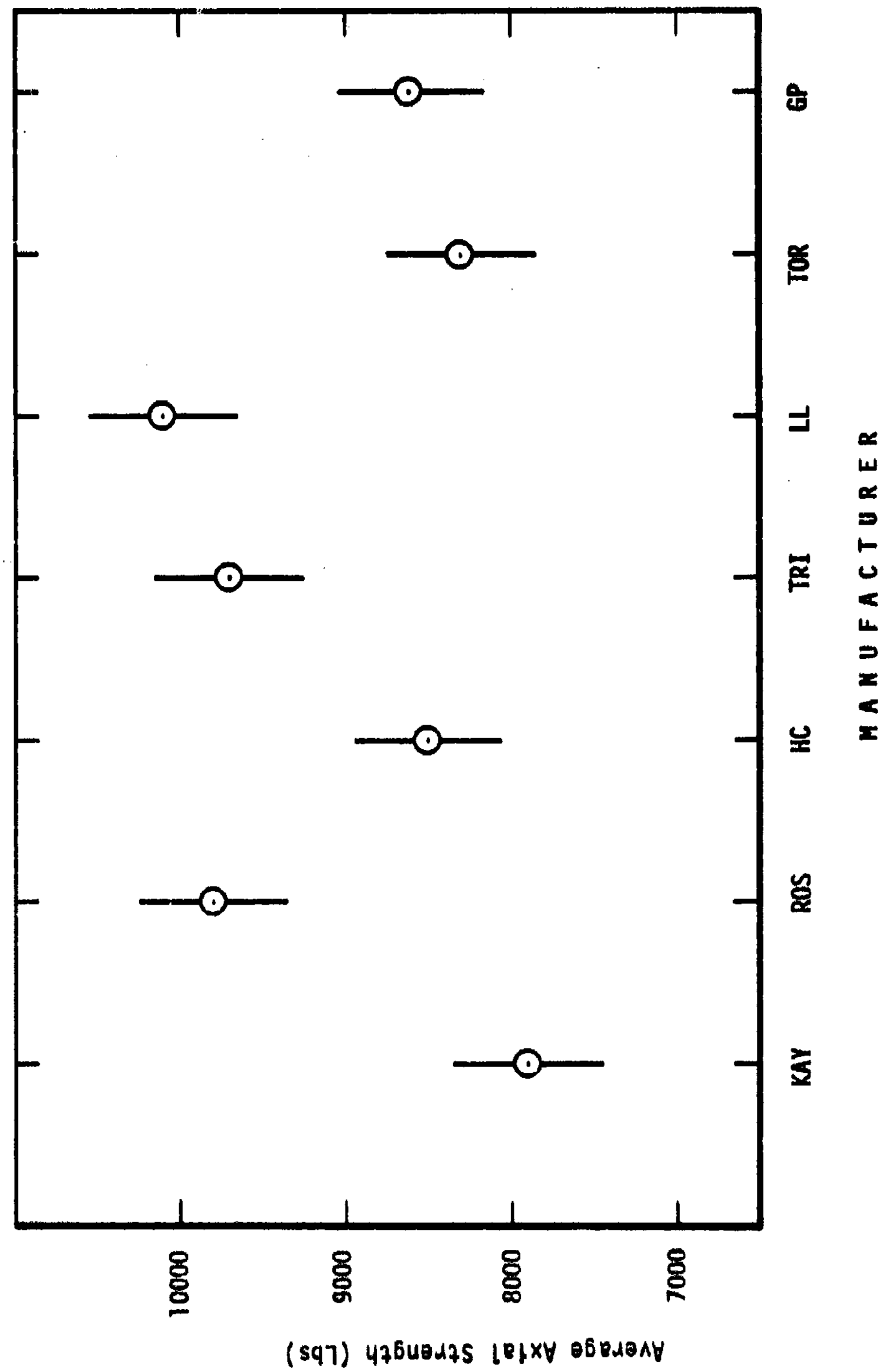


Figure 70. Average Axial Strengths - 1/4-28 Size Specimens

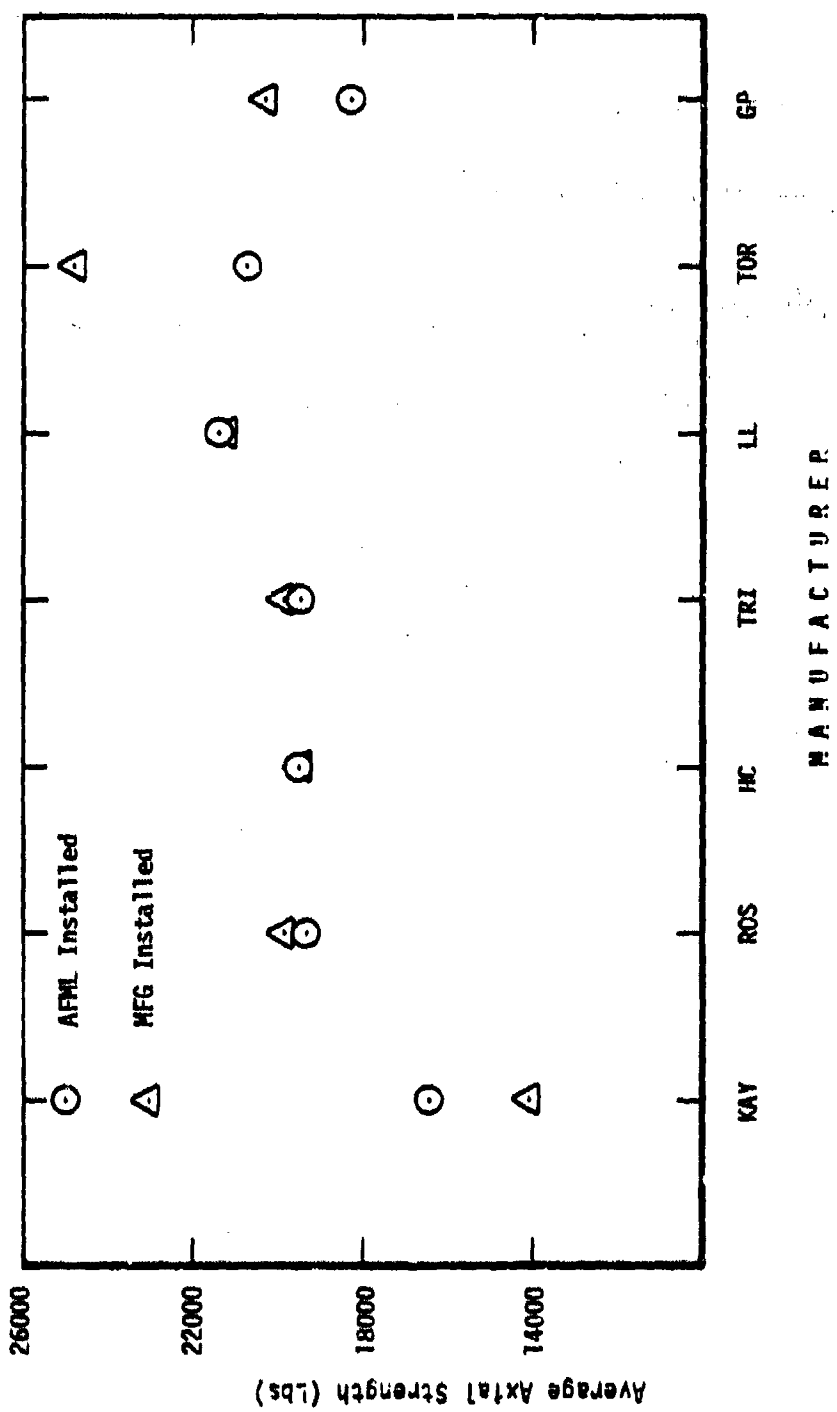


Figure 71. Average Axial Strengths - 3/8-24 Size Specimens

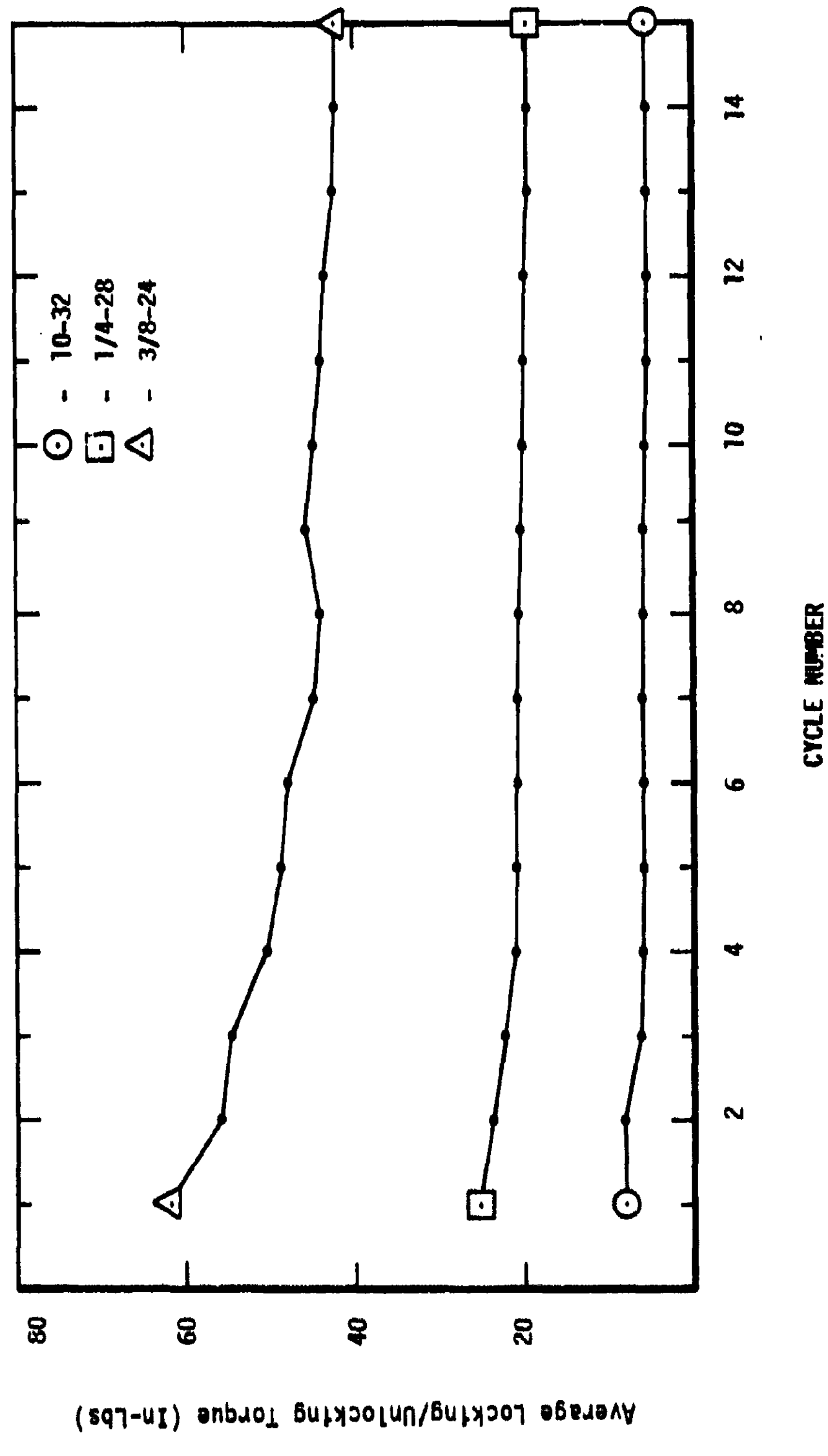


Figure 72. Average Bolt Locking/Unlocking Torques for Repeated Applications - Kaynar Inserts

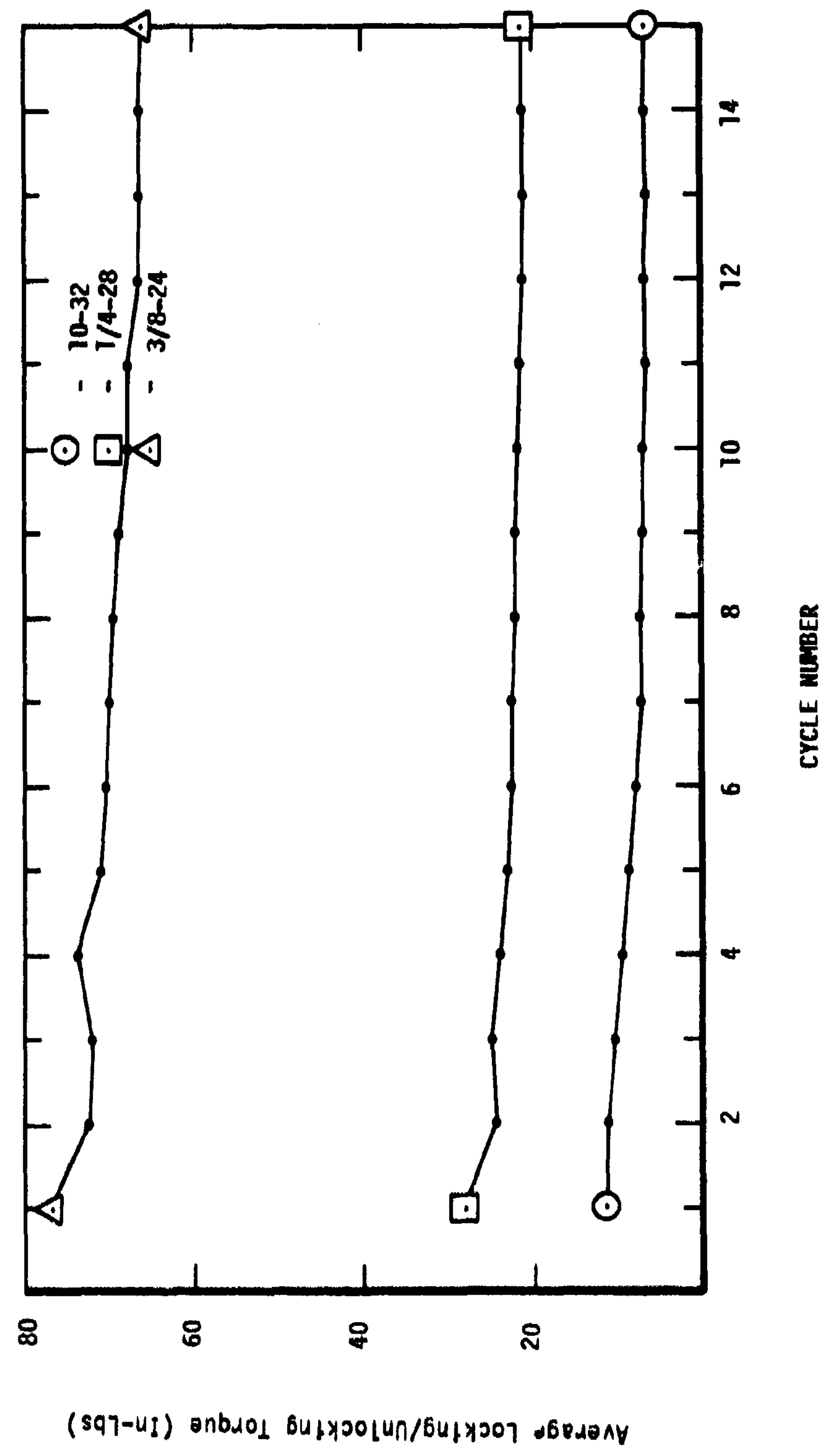


Figure 73. Average Bolt Locking/Unlocking Torques for Repeated Applications - Rosan Inserts

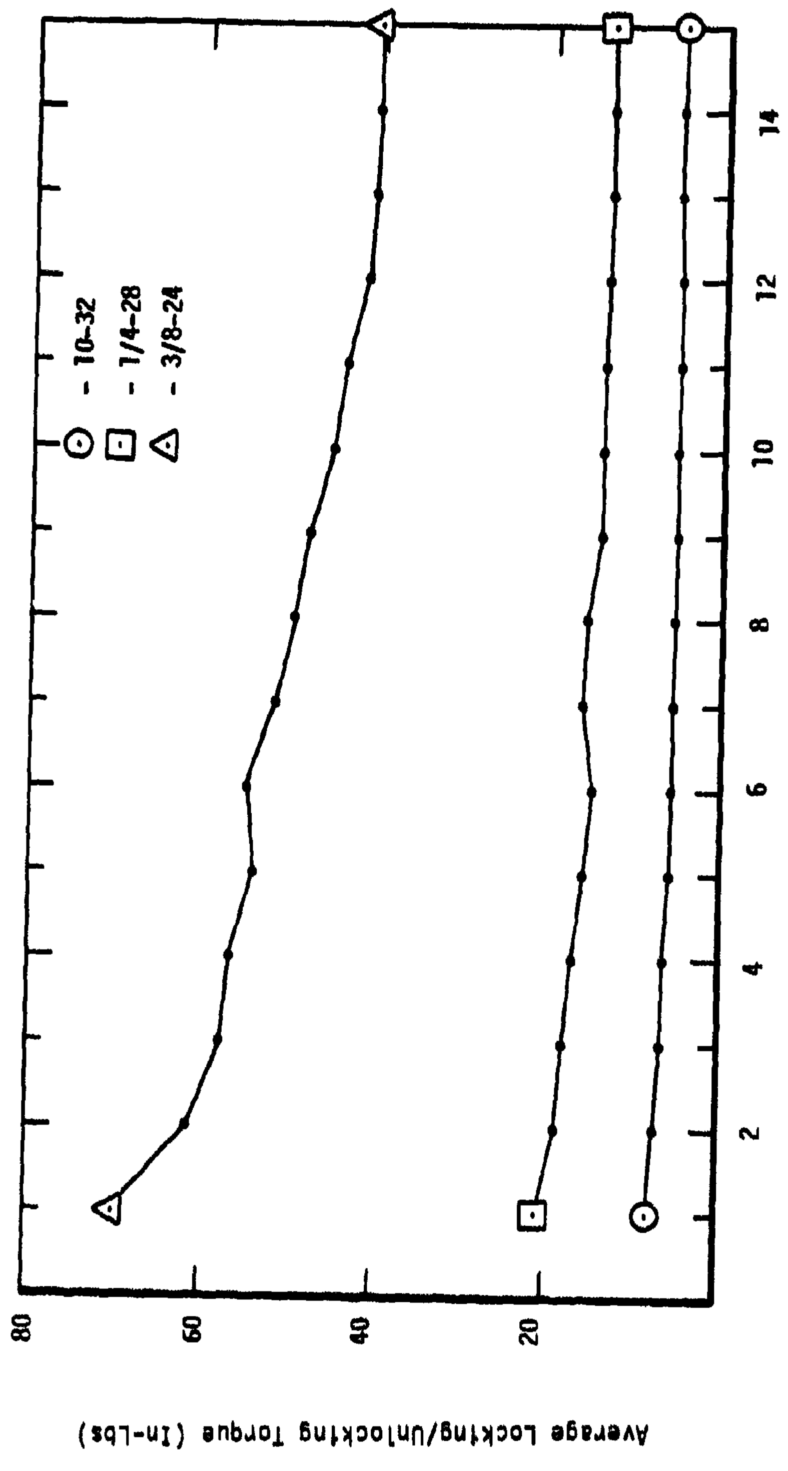


Figure 74. Average Bolt Locking/Unlocking Torques for Repeated Applications - Heli-Coil Inserts

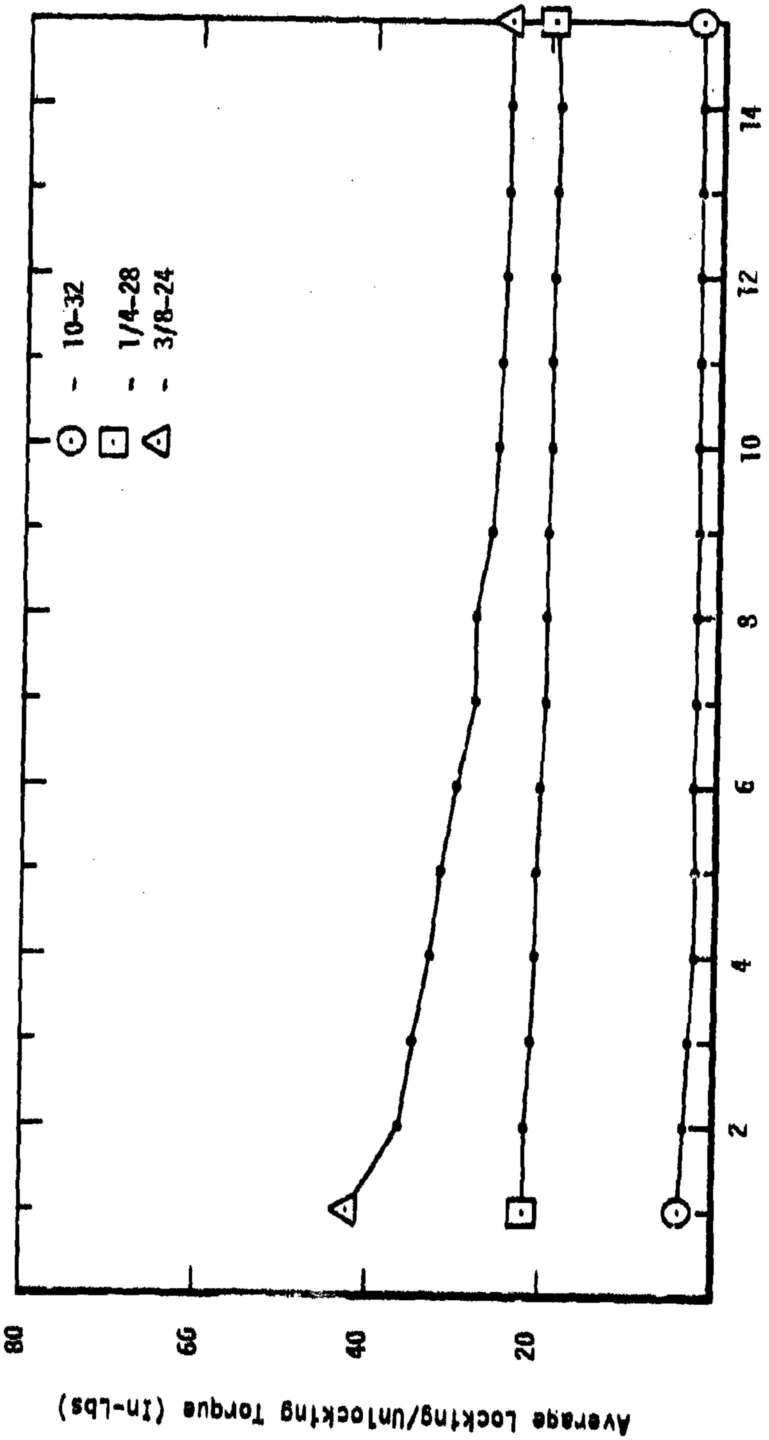


Figure 75. Average Bolt Locking/Unlocking Torques for Repeated Applications - Tridair Inserts

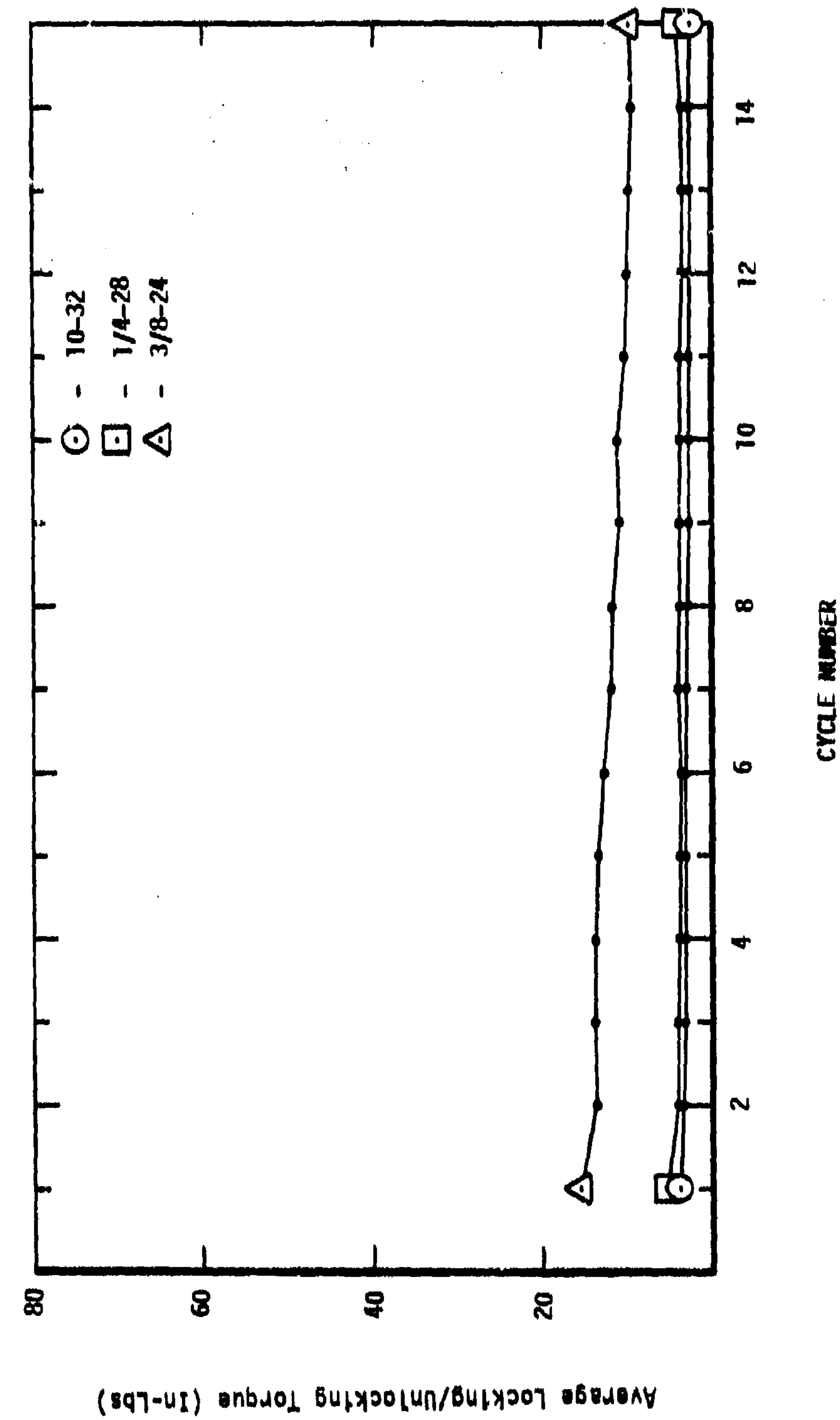


Figure 76. Average Bolt Locking/Unlocking Torques for Repeated Applications - Long-Lck Inserts

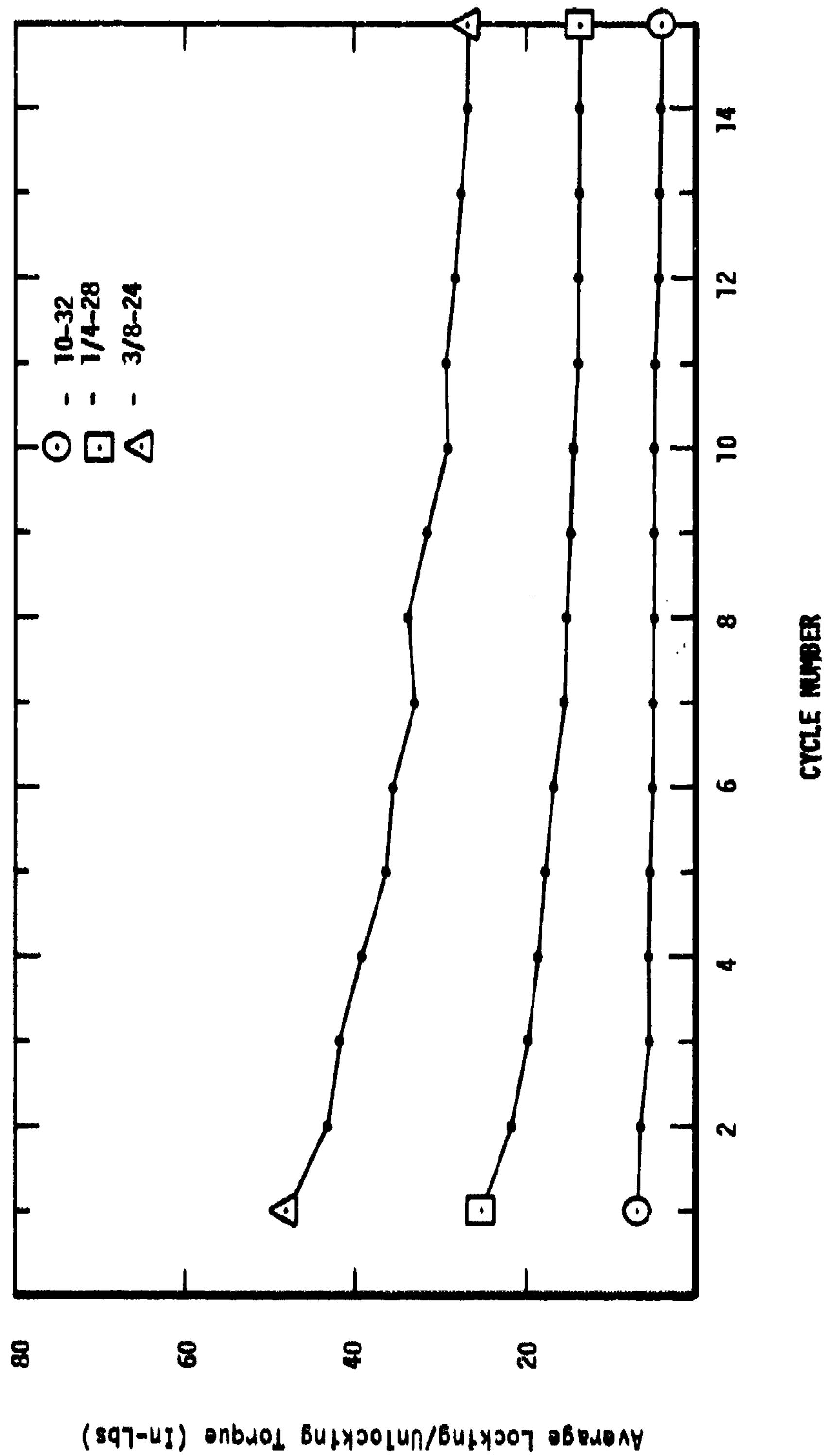


Figure 77. Average Bolt Locking/Unlocking Torques for Repeated Applications - Torkon Inserts

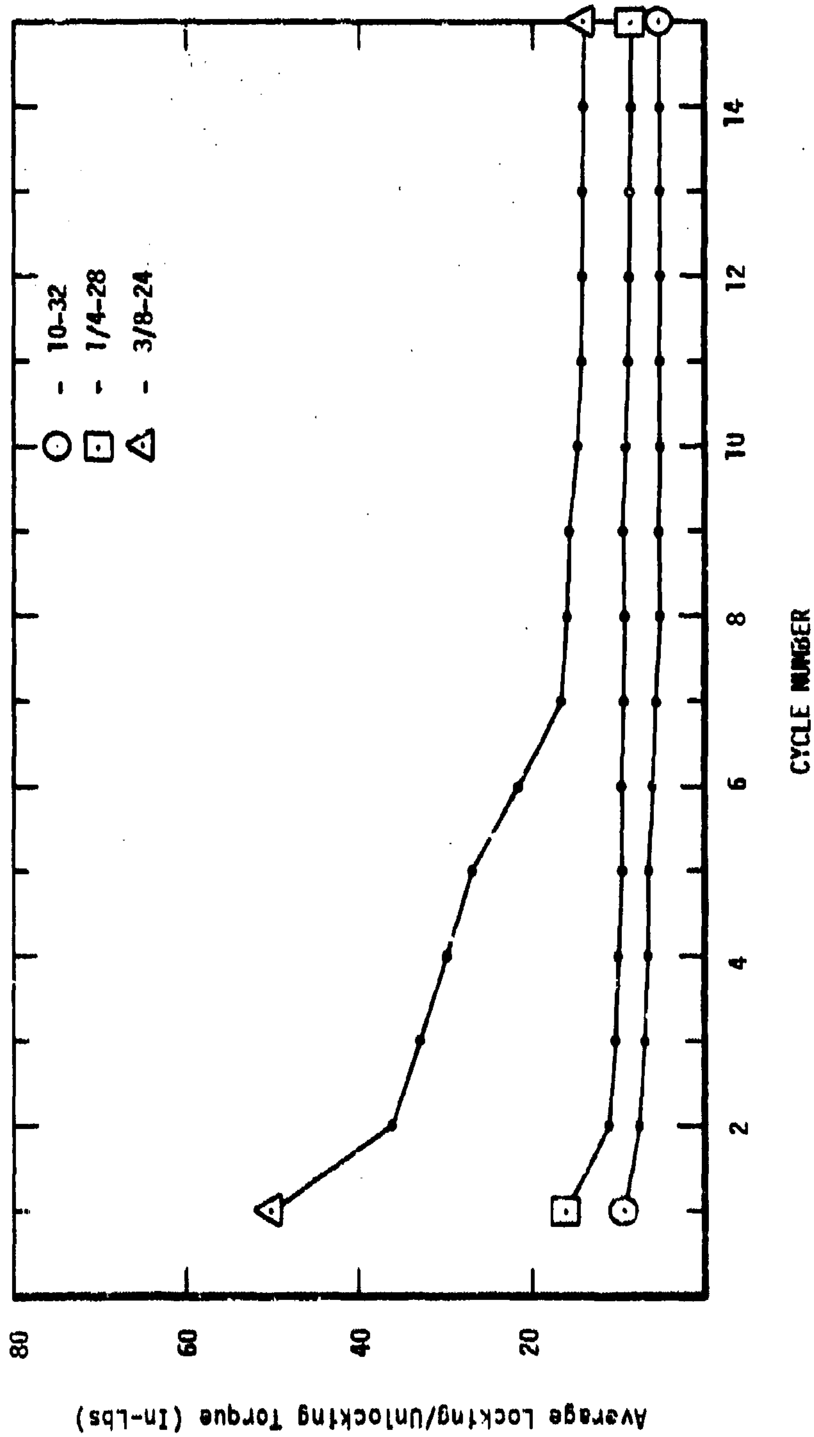


Figure 78. Average Bolt Locking/Unlocking Torques for Repeated Applications - Groov-Pin Inserts

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